

THE FRAUNHOFER SOCIETY:

A Unique German Contract Research Organization Comes to America

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for

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Forward

The Fraunhofer Society: A Unique German Contract Research Organization Comes to America describes a mechanism of industry, university, and government technology collaboration, which has played an important role in bridging the innovation gap in Germany, and is now establishing a presence in the United States.

Over the past two decades, U.S. Federal and State governments, often in collaboration with university and industry partners, have introduced a range of policies and programs designed to increase the effectiveness of research and development and enhance technology-based economic growth. In addition to these American initiatives, Germany has in recent years, through the Fraunhofer Society, been transferring to the United States its unique approach to technology deployment and development through government, university, and industry partnerships. The fact that six Fraunhofer facilities are now established in the United States, and a number of others are in the planning stage, suggests that this German model of innovation partnership may be addressing a gap in the United States innovation system. Recognizing that the strength of the United States innovation system is its “flexibility, adaptability, and diversity,” this report seeks to understand the dynamics of the U.S.-based Fraunhofer model and the challenges it represents to advancing U.S. industrial competitiveness.

To this end, the report reviews the German innovation system that gave rise to the Fraunhofer Society. It then describes the dynamics of the Fraunhofer Model and the factors resulting in its internationalization strategy. After examining the Fraunhofer’s growing presence in America, the report concludes with preliminary observations about what the Fraunhofer Model may mean to the U.S. innovation system.

We hope that this report will continue our tradition of providing the U.S. public and private sector organizations with the specialized information required to make decisions on technology-related questions.

Gary Bachula
Acting Under Secretary for Technology

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Executive Summary

THE FRAUNHOFER SOCIETY: A Unique German Contract Research Organization Comes to America

As the speed and cost of innovation increases, and research becomes global, governments around the world are assessing their national systems of innovation to better develop and implement policies that maximize national economic growth and industrial competitiveness. Increasingly, it is being recognized that success is conditional on optimizing the role and linkages of the main players in the science and technology system, that is, Federal and State governments, universities, and industry.

The Fraunhofer-Gesellschaft Society is a successful mechanism of industry, university, and government collaboration. Each Fraunhofer partner has a specific role that adds value to the partnership: universities undertake basic research and develop student/employees; government performs research at its own laboratories and provides funding to the Fraunhofer Society to keep the cost of contract research at a minimum; industry provides contracts and the manufacturing and marketing capability; and the Institutes themselves develop engineers and act as a conduit between basic research and industrial application. This interconnection creates considerable efficiencies in technology commercialization.

The interconnections also result in the Fraunhofer Society owning the “cycles of development,” that is, the intellectual property, whether patented or not, developed over the years as a result of carrying out hundreds, if not thousands, of public and private research contracts. These cycles of development include the development of new products, ideas, and materials that may not have been the intended output, but which nevertheless have commercial, industrial, or other potential. By exploiting the “cycles of development,” together with the other opportunities generated by their partners, the Fraunhofer Society has been able to expand their markets in Germany and abroad.

Since the beginning of the 1990s and the slow down of the German economy, the Fraunhofer Society has been following the trend established by German automotive and other manufacturers to

internationalize. This globalization strategy, coming after 40 years of concentrating on the German market, seeks to:

- Exploit new growth opportunities.
- Build a global networking system of business and technology contacts.
- Better serve multinational customers.
- Stimulate export of German technology and equipment.
- Promote Germany as an investment location.
- Penetrate new strategic business and technology fields.
- Expand the scope for industry and public sector contract research.

To this end, the Fraunhofer Society has, in just the last couple of years, opened a headquarter office in the United States, as well as three resource centers (with at least one more in the planning stages), two centers for research, one teaching factory, and has been considering two technology support services. This has resulted in the establishment of a presence in Michigan (two facilities), Massachusetts (one facility), Delaware (one facility), Rhode Island (one facility), Maryland (one facility), and Florida (one facility), with a site in Pennsylvania under discussion. Given the way in which the Fraunhofer Model operates, all of these U.S.-based facilities involve local state and university resources, as well as local industry partnering. Other sites are under review in Canada (forming automation center), Eastern Europe (application centers), South Africa (automotive center), and Asia.

The leveraging of investments in the United States by the Fraunhofer Society results in clients being able to have access to:

- Researchers and leaders who are able to bridge the gap between theory and application.
- Teaching and apprenticeship programs.
- The Fraunhofer Institutes' infrastructure in Germany.
- At-cost, world-class applied research and consulting.

In return, the Fraunhofer Society and its network of Institutes, which includes 59 establishments in Germany, receive:

- New markets for contract research.
- Exposure to U.S. and international techniques and innovations.
- Potential entry into U.S. markets for German suppliers associated with the Fraunhofer Society.

- The “cycles of development” that make up the process of solving a problem or developing a new product for an American company.

With the United States offering an extensive range of Federal and State cooperative technology programs, as well as world-class private sector contract research organizations, the rapid growth of the Fraunhofer Society, in partnership with various State governments and universities, raises questions as to whether gaps exist in the United States innovation system. In addition, the fact that the Fraunhofer Society receives substantial German government funds, and is mandated to promote German interests, raises concerns about the extent to which American corporate and economic development interests will ultimately be advanced. While it is beyond the scope of this paper to fully explore these questions, it is hoped that the understanding of the Fraunhofer Model that is presented will stimulate discussion of the following important public policy issues, among others:

- Will the German technology orientation of the Fraunhofer Society result in encouraging a dependency by U.S. companies on German machines, tools, and techniques?
- Does the Fraunhofer Model, developed in Germany’s “social market economy,” provide a competitive edge when applied in the United States “consumer-driven market economy?”
- Does the interest of the Fraunhofer Society in its own growth and development outweigh the economic development benefit sought by U.S. universities and State governments?
- Does the way the Fraunhofer Society structures its patent policy benefit the organization over its industry and university partners?
- Does the way in which the Fraunhofer Society exploits their “not-for-profit” tax status disadvantage potential “for-profit” competitors?
- If the Fraunhofer Society is addressing gaps in the U.S. innovation system, should similar linkages among U.S. universities, Federal and State governments, and industry be established to better promote U.S. competitiveness?

Part 1

THE GERMAN INNOVATION SYSTEM AND THE FRAUNHOFER SOCIETY

1.1. Introduction

As the speed and cost of innovation increases, and research becomes global, governments around the world are assessing their national systems of innovation to better develop and implement policies that maximize national industrial growth and competitiveness. To a considerable extent success is conditional on optimizing the role and linkages of the main players in the science and technology system, particularly with respect to public and private organizations. A key issue therefore, both in the United States and abroad, is how government can foster strategic cooperation among universities, research institutions, and industry to create or encourage mechanisms that bridge science, technology, and the marketplace.

This paper examines one very successful mechanism of industry, university, and government collaboration – Germany’s Fraunhofer-Gesellschaft and its organization of Institutes for application-oriented research. Operating as a market-driven “not-for-profit” organization, the Fraunhofer Society performs technology-oriented, project-based research for industry, the service sector, and government. By combining the resources of universities and government, it is able to help bridge the innovation gap and contribute to the rapid commercialization of technology. With the Fraunhofer Society in the process of expanding to North America, among other destinations, it is important to understand the reasons for its success in Germany in order to anticipate the challenge and opportunities it will represent abroad and appreciate the lessons it offers for government innovation policies.

First, though, the Fraunhofer Society needs to be considered in the context of the German economy and innovation system.

1.2. The German Social Market Economy

Germany is often described as an example of a social market economy – with high levels of State intervention, worker protection and business regulation¹. For much of its post-war history through to the end of the 1980s, which was marked by the Cold War and a divided Germany, this economy produced remarkable economic efficiency and fiscal discipline. In fact, Germany was often held to be the engine of

“Operating as a market-driven ‘not-for-profit’ organization, the Fraunhofer Society performs technology-oriented, project-based research for industry...”

Europe's economic growth – its strongest industrial economy and the monetary anchor for Continental stability. While its workers were among the highest paid, they also were among the most productive. An expanding economy meant expanding trade relations with the industrialized world. This in turn supported an expanding employment market that had to draw upon labor from nearby economies to meet demand.

During this period, the Fraunhofer-Gesellschaft, which was established in 1949, benefited from close collaboration with German Federal and State governments while contributing to the development of the nation's human and capital technology capabilities and markets. Its domestic expansion went hand in hand with Germany's economic growth. As Germany's high technology industry expanded the demand for R&D services, both in-house and contract organizations, similarly expanded. Though only one component of Germany's innovation and science and technology system, the Fraunhofer Society rapidly seized the opportunities presented by the German drive for new technologies.

In the 1990s, however, Germany's social market economy has been showing signs of strain. Along with many other countries, Germany is now confronted by the new global economy that arose out of the collapse of world communism and which has been institutionalized through the World Trade Organization. At the same time, with the tearing down of the Berlin Wall in November 1989, Germany has borne the staggering costs of East-West reunification. Consequently, the Germany that approaches the twenty-first century is more a model of high wages, over-regulation, expensive social programs, declining industries, and declining productivity. Exports, which account for one-third of all jobs in Germany, have been under-priced by lower-wage countries in Asia and Latin America. Germany's share of world exports, consequently, has declined more than any other large industrial nation. The current prospects are for a difficult transformation from a heavy manufacturing economy to a more knowledge intensive one.

One of the strategies for reversing Germany's economic fortunes is to "go international." While there have been German investments abroad for many decades, particularly in the areas of pharmaceuticals, chemicals, auto parts, and real estate, the movement overseas of key German industries surged in the 1990s. High manufacturing and labor costs, for example, forced many German automotive manufacturers to

invest in plants outside Germany, with much of this investment going to the United States. BMW and Mercedes both established vehicle assembly plants in the United States in the mid-1990s, and large parts suppliers such as Robert Bosch expanded their American manufacturing base through major acquisitions. The German Automobile Association predicts that more than half of the German supplier industry will invest in facilities outside Germany by 2000.

The Fraunhofer Society is now following the trend to internationalize established by German automotive and other manufacturers. The president of the Fraunhofer-Gesellschaft – Hans-Jurgen Warnecke – stated the globalization policy as follows:

“It is essential that we widen our horizons beyond the boundaries of regions, countries, or even European markets. The globalization of economic enterprise will affect export-oriented countries, such as ourselves, more than others².”

The Fraunhofer Society is off to a fast start on the road to becoming a global player. In just the last couple of years, the Fraunhofer Society has opened a resource office and five research centers in the United States and three representative offices in Asia. Other sites are under review in Canada (forming automation center), Eastern Europe (application centers), South Africa (automotive center), and Asia.

While these investments will offer considerable benefits to those U.S. interests that take advantage of Fraunhofer’s research services, it is important not to lose sight of the fact that the U.S.-based Centers also are expected to serve German-based interests. As described in various Fraunhofer Society promotional brochures, including the 1995 and 1996 Annual Reports, the overseas facilities are to support German technology development and international competitiveness by:

- Stimulating export of German technology and equipment.
- Promoting Germany as an investment location.
- Penetrating new strategic business and technology fields.
- Expanding the scope for industry and public sector contract research.
- Increasing German expertise through collaboration in technological initiatives of the host countries.

“The Fraunhofer Society is now following the trend to internationalize established by German automotive and other manufacturers.”

“Germany is one of the most research-intensive industrial countries in the world...”

“...the higher education system contributes to Germany’s innovation system through facilitating technology transfer at the local and regional levels...”

1.3. The German Science and Technology System

Germany is one of the most research-intensive industrial countries in the world, after Sweden, Japan, and the United States³. Its science and technology planning, policy-making and funding takes place on many levels and includes many institutional structures reflecting the nation’s Federal system and social market economy.

In 1993, German research and development (R&D) accounted for approximately 2.5 percent of gross domestic product, down from 2.9 percent before unification in 1990⁴. R&D in Germany grew from 34,550 million DM in 1975 to 65,252 million DM in 1993 in constant currency, representing real growth of 3.9 percent annually during the 17-year time period. In constant dollars, this is equivalent to \$15.7 billion in 1975 and \$29.6 billion in 1993.

Industry funds an increasing share of R&D in Germany, while the government share of support for research has decreased from 47 percent to 37 percent from 1975 to 1993. In 1995, 60 percent of total R&D spending was financed by industry, with more than two-thirds of science and technology activities carried out in industrial laboratories. In addition to conducting internal R&D, German industry also buys R&D results, mostly from other firms. It is the policy objective of the Federal government that industry’s commitment to funding and carrying out science and technology be maintained. For this reason, the Fraunhofer Society focuses their attention on the small- and medium-sized companies which have yet to “graduate” to their own in-house R&D capabilities.

The backbone of the German science and technology system is 70 research universities. These come under the authority of the 15 German States, though much of their funding is derived from Federal authorities. A complement to the university research system are the Fachhochschulen or technical institutions. Germany’s 125 Fachhochschulen, which focus on specific technical, managerial and social subject areas, increasingly play an important role in training students to apply science and technology. Overall, the higher education system contributes to Germany’s innovation system through facilitating technology transfer at the local and regional levels, qualified consultancy for industry, and in creating a link between regional requirements and applied research.

All of the 59 Fraunhofer Institutes and affiliated organizations are partnered with one or more of these universities. Through this arrangement the Fraunhofer Society obtains considerable technology resources – “student employees” who perform close to half of the contract research, and university professors who provide technology management expertise obtained from managing university basic research.

Germany also has a number of non-profit research organizations funded, to varying degrees, by the Federal and State governments. The Max Planck Society and its institutes are primarily devoted to basic research, but, unlike universities, can concentrate on selected key areas. The Hermann von Helmholtz Association of national research centers cover a wide spectrum of R&D, including mission-oriented or strategic research and development of industrial technology. The Fraunhofer-Gesellschaft and its network of Institutes for technology development and diffusion are included in this category as well.

The largest share of funds for university scientific research is provided by the German Research Association, an autonomous body that is legally a private association. Some 60 percent of the Association’s funds, however, come from the Federal government, chiefly the Ministry for Education, Science, Research and Technology (*Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie* or *BMBF*). The BMBF, which has responsibility for the general principles and the legal framework governing the publicly financed areas of science and technology, also contributes funds to the non-profit research organizations, including the Fraunhofer Society.

Cooperation between Federal and State authorities is facilitated through intermediate bodies, such as the Federal-State Commission for Educational Planning and Research Funding, and the Conference of Ministers of Education and Science. These bodies take on responsibility for coordinating higher education and research policy matters across the Federal Republic. The Fraunhofer Society has an advisory role to both the Federal and State authorities on the regional and national aspects of technology development and deployment.

Three current national R&D priorities are:

1. To increase support for basic research, strengthen research with long-term prospects, and expand “preventive research” (e.g., environmental, health, and climate).

“...though market-driven, the Fraunhofer Society does not have to rely exclusively upon the market to grow.”

2. To support industrial research in market-oriented technologies.
3. To improve the basic conditions for innovation in small- and medium-sized enterprises⁵.

Germany's government-funded research is increasingly promoting basic research. To this end, government funds are being directed toward promoting strategic technologies at the precompetitive stage (especially information technology, biotechnology, and materials research, transport, and energy research). The Fraunhofer Institutes, which receive as much as two-thirds of their revenues from a combination of government grants and funded projects, are an important part of Germany's innovation system for pursuing these priorities.

1.4. Filling the Innovation Gap in a Social Market Economy

Research boundaries among Institutes in Germany are well defined. In keeping with this practice, the mission of the Fraunhofer Society is application oriented and technical prototype development. While the Fraunhofer Society's market for industrial R&D contracts and other parts of the publicly funded research system is relatively small (it accounts for only 1.5 percent of German gross domestic expenditures on R&D), it carries considerable impact due to its strategic partnering with the university research system and role of advisor on government technology policy. In addition, though market-driven, the Fraunhofer Society does not have to rely exclusively upon the market to grow. Generous government funding supports the “public good” aspects of their technology development and deployment.

1.5. End Notes

¹ See for example: “Germans Falter in Struggle to Regain Competitive Edge” (The Wall Street Journal, June 12, 1997)

² Annual Report 1995 (Fraunhofer-Gesellschaft)

³ National Science Foundation Country Profiles: Germany (<http://www.nsf.gov/sbe/srs/nsf96316/german.htm>)

⁴ National Science Foundation Country Profiles: Germany (<http://www.nsf.gov/sbe/srs/nsf96316/german.htm>)

⁵ National Science Foundation Country Profiles: Germany (<http://www.nsf.gov/sbe/srs/nsf96316/german.htm>)

Part 2

THE DYNAMICS OF THE FRAUNHOFER MODEL OF GOVERNMENT-INDUSTRY PARTNERSHIPS

2.1. Fraunhofer Mission and Strategic Focus

The mission of the Fraunhofer Society is to develop technology through targeted projects in application oriented research and thereby expand markets for technology-intensive firms. To carry out its mission, the Fraunhofer Society is organized in a very unique way – individual Fraunhofer Institutes team local university expertise and German government funding with their state-of-the-art facilities to provide “integrated solutions” for technology development. Each Institute is also a center of excellence in a well-defined area and is prevented from working outside that area. The resulting institutional memory, concentration of resources, and knowledge is an essential part of the Fraunhofer Model and a key to its success. The various Institutes are networked, allowing for solutions to complex multidisciplinary problems. Although the Fraunhofer Society has a decentralized structure that emphasizes autonomy of the individual Institutes, it operates as one organization with uniform rules and contracts.

In carrying out its mission, the Fraunhofer Society has two strategic objectives. First, they help small- and medium-sized companies gain rapid access to innovations. Second, they acquire technologies of the future through long-term research¹. This results in considerable resources being invested in developing “effective methods of technology transfer.” Great importance is also attached to participating in “national and international technology programs to test their expertise in the face of global competition².”

2.2. The Fraunhofer Establishments

Fifty-nine Fraunhofer organizations have been established since 1949. They are located in all of the 15 German States (over 31 separate locations). These consist of 47 full-fledged Institutes, while another 12 are essentially Institutes-in-development. This latter category is somewhat contrived, created because of a prohibition on establishing new Institutes in West Germany since the period of East-West unification.

“Although the Fraunhofer Society has a decentralized structure that emphasizes autonomy of the individual Institutes, they operate as one organization with uniform rules and contracts.”

“With close to one-third of total costs covered by government grants, each Institute is able to market its full complement of research assets without having to cover total research process costs.”

Each Fraunhofer Institute, on average, consists of 100 employees, 70 engineering/science students (part-time), and a budget of 17 million DM (approx. \$10 million U.S.)³. All Fraunhofer Institutes are affiliated with local universities from which they obtain their labor pool of engineering/science doctoral students.

In 1995, the 47 Fraunhofer Institutes had a total budget of 1.3 billion DM (approx. \$750 million U.S.)⁴. Personnel consisted of 5,200 employees and 3,300 students and other part-time employees for an overall workforce of 8,500. Close to half of all employees were scientists and engineers.

2.3. The Fraunhofer Model

2.3.I. Government Funds Supplement Total Revenues

While competing with other private sector research institutions, the Fraunhofer Society has a unique advantage. At best, they need only earn 70 percent of their revenues from industry and government project research to grow. The remaining 30 percent of revenue is institutional funding (called “basic funding”) from the German government. Its purpose is to provide each Institute with the flexibility to pursue its own strategic research. With close to one-third of total costs covered by government grants, each Institute is able to market its full complement of research assets without having to cover total research process costs. This government funding is the driving force behind what is referred to as the Fraunhofer Model.

The Fraunhofer Institutes’ *industry revenues*, which average 30 percent of total revenues, are tied to contracts with private sector firms on specific projects. They provide a “reality check” that each Institute is relevant to its mandated technology field, such as materials and components, and is contributing to the overall Gesellschaft objective of developing technology and expanding markets for technology intensive firms. Just like a private firm, the Fraunhofer Institutes sign confidentiality agreements with their industrial parties to protect proprietary interests.

The Fraunhofer Institutes’ *public revenues*, which average 28 to 33 percent of total revenues, are tied to contracts for specific projects with German Federal and State governments. They also can include multilateral sources such as the European Union (sometimes as much as 50 percent of total revenue for individual Institutes). They provide a “reality check” that each Institute is at the forefront of public interest

research such as environment, and health and safety. Just as in the case of private firm contracts, these funds are earmarked against deliverables. However, when government project funds are involved, the Institutes are not able to sign full confidentiality agreements. Government rules require that all costs be tracked and accounted for to the government sponsor. This has implications for consortium projects involving government and company partners.

The Fraunhofer Institutes' *basic or government grants* are not tied to deliverables. Rather, they can be used for whatever an individual Institute believes will best advance their strategic plan and assets. Generally amounting to 25 to 33 percent of total revenues, the funds are made up of contributions from both the Federal and State governments (based on a ratio of 90 and 10 percent respectively). All revenues are cash; there are no in-kind contributions. These funds enable each Institute to invest in long-term technology development by acquiring the latest laboratory equipment and undertaking long-term application-oriented research, thereby providing the stability to be innovative. In addition, they represent a powerful marketing tool – clients gain tangible economic benefits from the investment capital which precedes work on any particular application.

The Fraunhofer Society matching fund shares formula⁵ can be depicted as follows:

**TABLE I:
FRAUNHOFER MATCHING FUND GENERAL FORMULA**

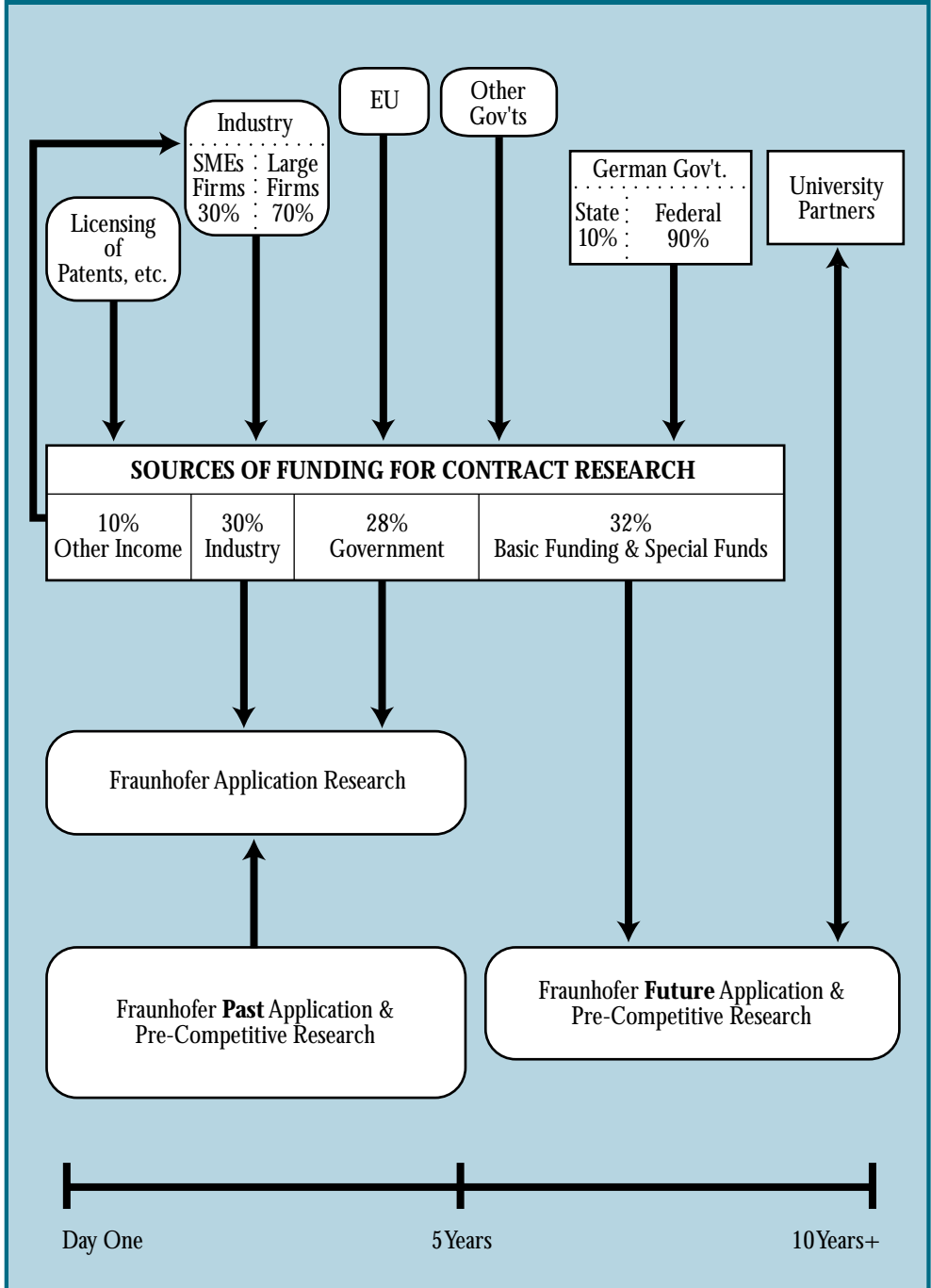
REVENUE SOURCE		% FUNDING SHARE
If		
Industry Contracts	=	33&1/3
+		
Public Contracts	=	33&1/3
Then		
Basic Funding (government grant via Munich HQ)=		33&1/3

When one combines the Fraunhofer Society funding formula with its source of revenues and breakout of pre-competitive and application-oriented research, the following illustration of the Fraunhofer Model emerges (based on 1993 data for sources of funding for contract research in West Germany):

ILLUSTRATION I:

THE FRAUNHOFER MODEL:

SOURCES OF REVENUE, FUNDING FORMULAE AND RESEARCH OUTPUT



It should be noted that there is considerable flexibility built into the Fraunhofer Society funding ratios due to research priorities. For example, the Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg receives a much greater basic funding ratio (80 percent) because its work on solar energy systems development is driven more by public interest than private sector contracts (i.e., it is 5 to 10 years in advance of industry). On the other hand, some Fraunhofer Institutes may receive as much as 70 percent of their funding from industry. Since each of the 59 Fraunhofer organizations have a different overhead, their actual funding ratios are determined on a case by case basis.

2.3.II. Research Performed by High-Skilled Low-Cost Students

The second driving force of the Fraunhofer Model in Germany is that each Institute partners with one or more local universities. This partnership enables the Fraunhofer Institutes to bridge the innovation gap between university basic research and the technology needs of industry. Not only do the universities provide a significant portion of each Institutes' workforce, but more than half of the Institutes are headed by active university professors.

The universities transfer technology to the Fraunhofer Institutes by providing access to the technical expertise and basic research of both professors and advanced degree students. In fact, the Fraunhofer Model could not function at all if students, which account for close to 40 percent of the 8,500 employees, were not involved in the contract research. This use of students bears some resemblance to the practice of medical interns in hospitals – long hours, low pay – while delivering all the services expected of a fully licensed and much more expensive doctor. The benefit to the Fraunhofer Institutes is that they obtain access to leading-edge expertise at less than commercial rates. The annual 10 percent turnover rate means that each Institute is constantly “creaming the best and the brightest” engineers and scientists. The benefit for the university partners and participating students is that Fraunhofer Institutes' industrial and public sector research contracts, combined with their state-of-the-art technology, provide an opportunity to advance knowledge and know-how beyond the constraints of university resources.

The student/employees work full-time on Fraunhofer projects for a period of five years on average. During this time they are also

“The benefit to the Fraunhofer Institutes is that they obtain access to leading edge expertise at less than commercial rates.”

working toward completion of their Ph.D., though most academic work is done on their own time. Generally, as the students complete their fifth year at a Fraunhofer Institute, they also complete their Ph.D. requirements. With these two achievements in hand, the student/employees “graduate” to full-time employment in industry as distinguished Fraunhofer Ph.D.’s.

While at a Fraunhofer Institute, the students are expected to conduct themselves like entrepreneurs. They are responsible for not only full management of their immediate projects but also the marketing of the Fraunhofer Society’s overall expertise. Just as the Fraunhofer Institutes operate on the basis of achieving revenue ratios from industry, so too must the student employees. Some students, for example, earn as much as 400,000 DMs a year in project revenues, with 50 percent derived from industry work.

Given the way the Fraunhofer Institutes employ students, by the time they “graduate” to industry they will have acquired leading-edge technical expertise, trained in the full range of business skills necessary to function as an “entrepreneur,” and been exposed to an extensive network of business contacts. The five year investment generally will double the income that they would otherwise expect if they entered industry with just a Ph.D. alone.

2.3.III. Contract Research Captures “Cycles of Development”

Drawing upon government funding and university resources to pursue public and private contract research, the Fraunhofer Society is positioned to capture the “cycles of development” that make up the process of solving a problem or developing a new product for a company. The cycles of development refer to the step-by-step process of solving a problem or creating a new product. This may include the intellectual property developed by “trial and error” and moving in a new direction to meet a particular goal. It also may include the development of new products, ideas, and materials that were not the intended output, but which have commercial, industrial, or other potential. In short, the Fraunhofer Model is not only distinguished by its ability to partner in order to maximize problem solving capabilities, but also by its ability to retain the knowledge of how to solve problems that flow from the subsequent contract research. This knowledge, in turn, serves as an important marketing tool for building both the research partnerships and customer base.

2.3.IV. Patent Policy Gives Edge in Controlling Technology

While the Fraunhofer Society patent policy results in industry contracts being able to benefit from the thousands of patents generated over nearly five decades, the real beneficiary is the Fraunhofer organization itself. Most technology innovations are registered by the Institute, not the industry and university partners. As noted in a recent binational panel on technology transfer systems in the United States and Germany:

“In most cases, inventions created within research projects are not given directly to industry but registered by the Institute itself. An industrial partner generally gets an exclusive license, but only for the partner’s special application; hence, the [Fraunhofer] FhG is free to license the patented technology to another company for a different application. With more than 200 domestic patent applications in 1993, the FhG is among the most active patent assignees in Germany⁶.”

2.3.V. Not-for-Profit Status Allows Pursuit of Innovation Gap

The teaming of university expertise and government funding is given legal identity through the Fraunhofer Society’s not-for-profit status (registered as a public utility association in Germany). What this means is that the Fraunhofer Society will cover all costs but not directly profit from the commercialization of new technology or innovation. Rather, the Fraunhofer Society “develops processes and methods as well as products for their customers up to their introduction to the market⁷.” Furthermore, Fraunhofer Society employees, regardless of which Institute or where in the country they work, are covered by a pay and benefits scheme more in keeping with government rates than commercial ones. However, as an alternative to corporate profits and employee bonuses, success in achieving the Fraunhofer Society mission results is an annual government subsidy of as much as 30 percent of total revenues. This enables the Fraunhofer Society and their employees to remain in the forefront of technology development and diffusion which can be leveraged for more highly compensated positions in industry at a later date.

“In most cases, inventions created within research projects are not given directly to Industry but registered by the Institute itself...”

“The teaming of university expertise and government funding is given legal identity through the Fraunhofer Society’s not-for-profit status...”

2.4. The Fraunhofer Organization

2.4.I. Administration

The Fraunhofer Society has a decentralized organizational structure. While the 47 Fraunhofer Institutes are administered by the Fraunhofer-Gesellschaft or headquarters, based in Munich, and the 12 Fraunhofer Institutes-in-development are administered by the Fraunhofer Management Society, also in Munich, each entity operates as an independent “profit center” in close partnership with regional industry.

“The leaders of the individual Institutes are trained researchers who have succeeded within the Fraunhofer system. . .”

The Fraunhofer Institutes are led by an independent president who is Chairman of the Executive Board of the Fraunhofer-Gesellschaft. This body, which is supervised by a Senate comprised of private and public sector representatives, is responsible for decisions that affect the Institutes as a group. The leaders of the individual Institutes are trained researchers who have succeeded within the Fraunhofer system, not only because they have excelled in their field of technical expertise, but also because they are able to work with and serve parties with contrasting goals. Heads of the Fraunhofer Institutes are able to speak the language of academe because they are often full university professors and at the same time understand and meet the needs of industry.

2.4.II. Strategic Direction

The Fraunhofer Institutes receive strategic guidance from their headquarters in Munich. This strategic guidance relates to the individual Institute’s mission of developing technology and expanding markets for technology intensive firms by facilitating technology transfer to small- and medium-sized firms and participating in national and international technology programs to acquire technologies-of-the-future. It is often developed in consultation with German Federal and State governments.

Within this strategic direction each Institute is able to determine its own research fields, that is, research emphasis, project acquisition, project management, and results. They are also responsible for balancing their budgets. In keeping with the Fraunhofer Model, however, the 30 percent of revenues derived from government grants is negotiated annually with the Gesellschaft Executive Board. It is awarded on the basis of each Institute meeting its past year’s

performance ratios and the ratio of industry income projected for the following year. Funding is not ensured because all the Institutes compete with one another for their share of the same pool of funds, which will rise or fall in any particular year according to the resources of government.

2.5. Fraunhofer Contract Research

2.5.I. Capabilities

The Fraunhofer Society offers a number of very important strengths to their contract partnerships. First and foremost, it can draw upon almost 50 years of institutional memory, applied research skills and experience, and the expensive precompetitive research which precedes work on specific projects. Second, it has available research managers and leaders who bridge the gap between the universities and industry, speaking the language of the theorists, but understanding the needs of industry. Third, its researchers generally have at least five years of manufacturing experience in addition to their Ph.D., and are trained to work in teams and solve problems together in a timely manner. This collaborative research network enables the Institutes to provide clients with “tangible solutions to problems and applications or the evaluation and implementation of innovative technologies⁸.”

2.5.II. Research Fields

The Fraunhofer Society collectively offers expertise in eight different research fields, though each Institute specializes in only one aspect of a particular field and is prevented through an arrangement with the Gesellschaft to do work outside of its mandate. They are encouraged, however, to draw upon the expertise of any or all of the other Fraunhofer Institutes if this supports the interests of a particular client’s work, especially when systems solutions are required.

The eight research fields are described by the Fraunhofer-Gesellschaft as follows⁹:

1. Materials and Components

Twelve Institutes, employing some 1,800 persons, are involved in the development of new materials such as ceramics, hard metals, metal foams, compound materials, inorganic-organic polymers, nano-crystalline powder, wood materials, and the development of new coating materials and surface technologies.

“The Fraunhofer Society collectively offers expertise in eight different research fields, though each Institute specializes in only one aspect of a particular field and is prevented through its arrangement with the Gesellschaft to do work outside of its mandated area.”

2. Microelectronics and Microsystems

Seven Institutes, employing some 1,600 persons, conduct research into semi-conductors for high and highest-level circuits on the basis of silicon and gallium arsenide, related production equipment, the development of digital, analog and hybrid circuits, microsystems technology using integrated sensors, actuators, and related mounting and connection technology.

3. Production Technology

Twelve Institutes, employing some 1,400 persons, are involved in the planning, simulation, and automation of complex manufacturing processes, the conception and layout of flexible production facilities, logistics, quality assurance and machine-tool control systems, the “fractal company” and rapid prototyping.

4. Information and Communication

Eight Institutes, employing some 1,000 persons, are involved in image processing and pattern recognition, visualization, interaction and communications technologies, control and automation technology with expert or fuzzy control systems, graphical data processing for multimedia and electronic publishing, telecommunications for computer-supported work, and improvements to the interfaces between operator and machine.

5. Energy, Construction, Environment, Health

Four Institutes, employing some 950 persons, conduct research into solar power, low-energy houses, environmental chemical and pharmaceutical health research, ecotoxicological evaluation of chemicals and analysis of atmospheric pollution aimed at improving environmental protection.

6. Process Engineering

Seven Institutes, employing some 800 persons, conduct research on biotechnology, food packaging and environmental process technology, membrane and polymer technology with technical exploitation of regenerative raw materials, and the development of chemical energy sources.

7. Sensor Systems, Testing Technologies

Eight Institutes, employing some 500 persons, perform non-destructive testing using ultrasound or electromagnetic resonance for applications in material testing and medicine,

optical and acoustic processes of quality control, laser spectrometers, laser-optical and holographic measurement techniques, micro-optics and integrated optics.

8. Technical and Economic Studies

Five Institutes, employing some 495 persons, perform interdisciplinary technological analysis, evaluations, and forecasts to facilitate decision-making and long-term planning in industry and government.

The traditional focus of the Fraunhofer Society has been on the technological research and development related to the manufacture of discrete products. Changes in the marketplace have led to the foundation of Institutes working in the fields of logistics, work sciences, and business processes. Increasingly, when faced with interdisciplinary problems, individual Institutes will work together to develop solutions.

Four Fraunhofer Institutes also conduct research for the Federal Ministry of Defense. This type of work though is being phased-out as a result of the end of the Cold War refocusing priorities to the civilian economy.

Finally, the Fraunhofer-Gesellschaft is planning to set up two innovation centers to help close the gap between Institutes and the market. These centers will be totally private, and profit oriented. Since they will receive no public money, they will have to survive solely through contracts with industry. One of the centers will focus on polymer recycling linked to food technology and packaging and the other on telecommunications and multimedia.

2.5.III. Range of Services

Within any one research field, Fraunhofer Institute services include¹¹:

1. Optimization of product and process techniques, development of prototypes and new processes.
2. Support in the introduction of new technologies and of organizational and operating methods.
3. Technological consultancy in the form of:
 - technology information and advice using approximately 24 application centers, including hands-on training
 - feasibility studies

“...the Fraunhofer-Gesellschaft is planning to set up two innovation centers to help close the gap between Institutes and the market.”

- market surveys
 - technology and manufacturing trend analysis
 - calculation of economic viability
 - information on availability of financial support, particularly for small- and medium-sized companies
 - certification and attestation of quality and safety.
4. Advice on the availability of government funding programs for innovation in products and processes¹².

In addition, some Institutes provide specialized services. The Fraunhofer Institute for Production Technology in Aachen, for example, offers customized technology calendars. These illustrate the time scale within which different technologies hold a promise of market success. Also, the Fraunhofer Institute for Systems and Innovation Research in Karlsruhe offers a new patents information service. This is particularly useful to small- and medium-sized companies in need of an inexpensive way of researching patents for both technology and market insight.

2.5.IV. Customer Base

Each year, the Fraunhofer-Gesellschaft provides its services to some 2,700 industry and government clients worldwide (of which 250 are foreign companies). Contracts from industry represent on average 30 percent and projects financed from government 28 percent of total funding.

Traditionally, small- and medium-sized companies are a very important part of the German industrial landscape. A major portion of the Fraunhofer Society's activities, accordingly, is devoted to these companies. In fact, the Fraunhofer Society's core mission is to provide assistance to SMEs in gaining rapid access to innovations. Since the German government regards SMEs as offering the greatest potential for creating new jobs "special supplementary funding is available to promote such collaborative work¹³."

According to the 1996 funding primer of the BMBF (*Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie*), the possibilities for SMEs to develop SME-typical technologies using resources from the BMBF or the EC are limited. This is in contrast to the opportunities provided to large companies. Therefore, the Fraunhofer Society is expected to use part of their basic funding to develop technologies that address the needs of SMEs.

However, the fact that small- and medium-sized companies represent only 10 percent of total Fraunhofer Society earnings suggests that in an era of shrinking public funding, the organization will be more inclined to go to greater lengths to satisfy the clients that represent over half of their contract earnings – large industry and public bodies. It is necessary for the Fraunhofer Society to maintain ties with smaller companies to serve the public interest but, at the same time, focus on its mainstay: large industry contracts, both in Germany and abroad.

With respect to public clients, most work is through the German Federal and State governments, the German Society for the Advancement of Scientific Research, other national governments (mostly European), and the European Union. The Fraunhofer-Gesellschaft emphasizes that these programs “allow strategic research to be conducted which is of interest to society at large,” such as “energy, solutions to traffic and environmental problems, and the need to develop key technologies¹⁴.”

2.5.V. Marketing

Through various promotional brochures, the Fraunhofer Society promotes its contract research by emphasizing the following advantages:

- State-of-the-art laboratory equipment and scientific aids such as project management and internationally linked communications systems enhance the quality of the research.
- More than 2,600 experts are available for the development of complete systems.
- All developments are based on profitability consideration.
- Detailed project reports, instructions for use, staff training and complete introduction strategies for new technologies round off the contract research services.
- Reliability, continuity and service of a large organization are available to all companies.

In 1990, the Fraunhofer-Gesellschaft founded its subsidiary company, Fraunhofer-Management-Gesellschaft, for the purpose of marketing its expertise in research management. The range of services offered includes:

- R&D consulting.
- Planning, organization and supervision of research institutions.
- Provision of the latest management tools.
- Management of complete technology projects.

“It is necessary for the Fraunhofer Society to maintain ties with smaller companies to serve the public interest but at the same time, focus on its mainstay: large industry contracts, both in Germany and abroad.”

“Individual Institutes play an active role in the economic development of the region where they are located in Germany.”

The Fraunhofer-Management-Gesellschaft is also actively involved in establishing an efficient R&D infrastructure in countries outside Germany through its participation in projects in Hungary, Spain, Poland, and Malaysia.

2.6. Fraunhofer Government Relations

2.6.I. Economic Development

Individual Institutes play an active role in the economic development of the region where they are located in Germany. The Institutes not only provide sources of employment, but contribute to building small- and medium-sized enterprises as well as collaborating with the larger industries in the region. The Fraunhofer research laboratories, researchers, and equipment also attract companies to the region, adding to the tax and employment base. Given these benefits, German State governments are more than happy to contribute to Fraunhofer Society “basic financing” when they have one or more of the Institutes located within their jurisdiction. With strategic guidance from the Gesellschaft or headquarters in Munich, the Institutes, in essence, are empowered to make industrial policy decisions for Germany without the need for direct input from the Federal Government.

2.6.II. Technology Policy Development

Beyond undertaking specific industry and project research projects, the Fraunhofer-Gesellschaft plays an active role shaping German technology policy and programs¹⁵. Given the importance of technology, especially technology-based exports to the German economy, it is the declared policy of the Fraunhofer-Gesellschaft “to grasp the initiative in presenting new concepts for such technology to government and industry, and thus to provide the impetus for new research projects¹⁶.” To this end, the Fraunhofer Institute for Systems Technology and Innovations Research (ISI) advises the German Federal Ministry of Research and Technology and the Technology Assessment Unit of the Federal German Parliament on the strategic development of the technology development efforts¹⁷.

2.7. Fraunhofer International Contract Research

While most of the Fraunhofer Society’s contract research is directed at expanding technology markets for German firms, some 12 percent

results from international collaboration. Most of this work involves research programs administered by the European Union that are intended to improve the competitiveness of European industry through the enhancement of technical systems and processes¹⁸. The main focus of the almost 200 Fraunhofer European Union (EU) projects are materials research (BRITE-EURAM), data processing technology (ESPRIT), communications technology (RACE), and technology transfer (SPRINT)¹⁹. In recent years, EU programs have generated approximately 31 million DM worth of revenues. While these programs provide access to strategically important projects and networking, the fact that only 50 percent of the costs are covered by the EU limits the ability of the Fraunhofer to expand its involvement.

To promote its interests in obtaining EU-sponsored research work, the Fraunhofer-Gesellschaft is a member of the European Association of Contract Research Organizations (EACRO). The Fraunhofer-Gesellschaft is also an active participant in international panels, advisory committees, and planning groups. As a result of this involvement, the Fraunhofer Society's management has an influential vote in setting the course of research policies, both in Germany and in Europe²⁰.

With respect to contract research for other national governments, the most important country is the United States, which accounted for some 14 million DM in 1997. Other significant countries, in declining order of importance, include Switzerland, Austria, Italy, Netherlands, Great Britain, France, the Republic of Korea, Sweden, and Denmark. In total, the international contracts represent annually approximately 40 million DM worth of business. It is interesting to note that the Fraunhofer does not do any significant business with Japan.

While the combined EU and international contract research in recent years have averaged 75 million DM, this barely represents 4 percent of total Fraunhofer revenues. This demonstrates the importance of the German market, as well as the challenge to future growth, which increasingly will have to be based upon developing markets outside of Germany.

2.8. The Essence of the Fraunhofer Model

Given the Fraunhofer Society's profile, the Fraunhofer Model can be distilled into its essential features as in Illustration II on page 37. It is

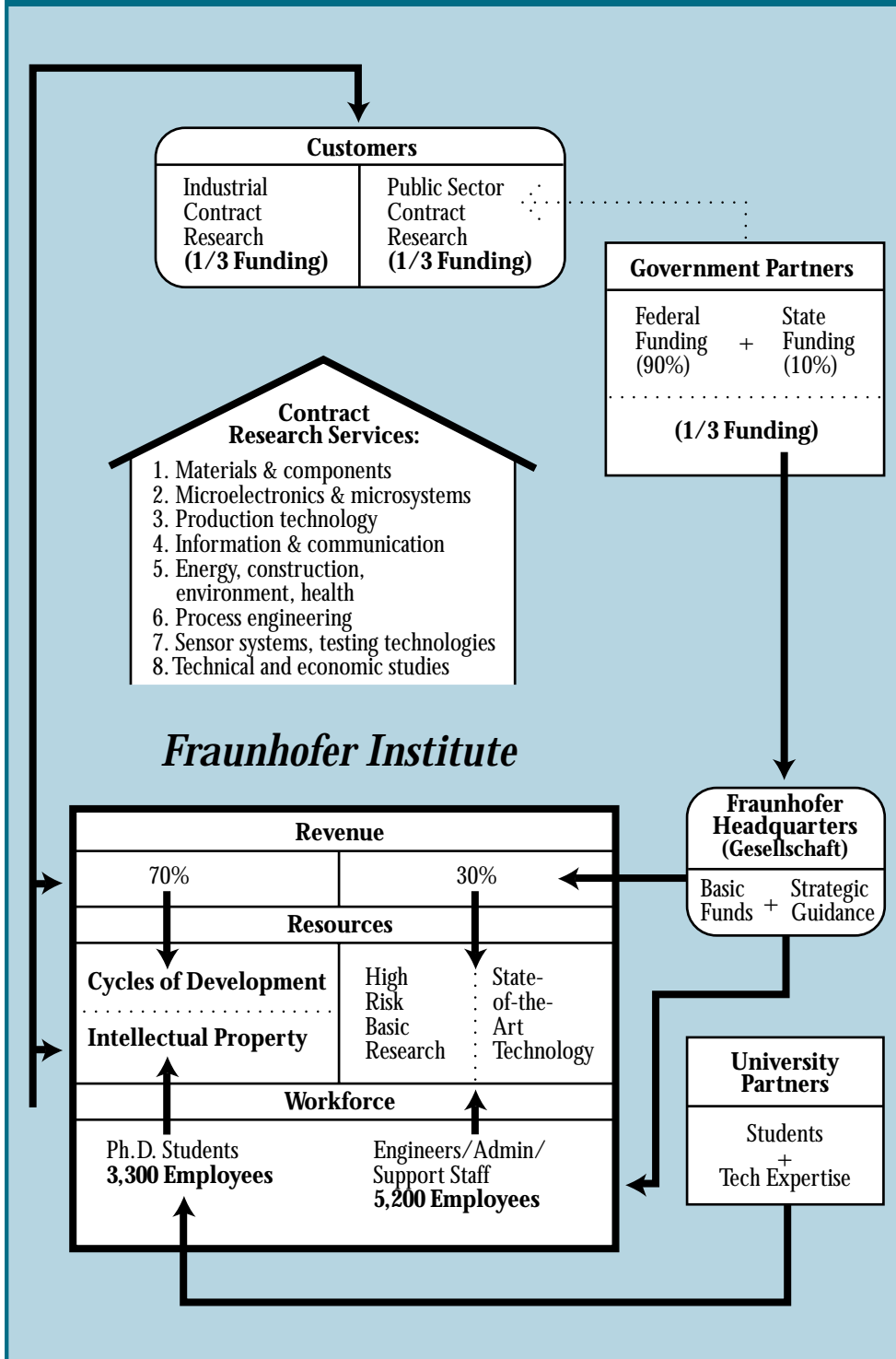
"...the Fraunhofer Society's management has an influential vote in setting the course of research policies, both in Germany and in Europe."

“In its capacity as an applied research organization, the Fraunhofer Society successfully expedites technology transfer between the universities, government and industry.”

within the Fraunhofer Institutes and Resource Centers that theory and application oriented research are turned into commercially or industrially viable products. In its capacity as an applied research organization, the Fraunhofer Society successfully expedites technology transfer among the universities, government, and industry.

Each organization has a specific role that adds value to the model: universities undertake basic research and develop student/employees; government performs research at its own laboratories and provides basic funding to the Fraunhofer Society to keep the cost of contract research at a minimum; industry provides contracts and the manufacturing and marketing capability; and the Institutes themselves develop engineers and act as a conduit between pre-competitive and industrial application. This interconnection creates considerable efficiencies in technology transfer. Most important, in terms of strategic development, the interconnections result in the Fraunhofer Society owning the “cycles of development,” that is, the intellectual property developed by trial and error and moving in a new direction to meet the technology goal. These cycles may also include the development of new products, ideas, and materials that were not the intended output, but have commercial, industrial, or other potential. By exploiting the “cycles of development,” together with the other opportunities generated by their partners, the Fraunhofer Society is able to expand markets and grow.

ILLUSTRATION II: THE FULL FRAUNHOFER MODEL



2.9 End Notes

- ¹ Fraunhofer International: Advancing a Worldwide Partnership in Research and Development (Fraunhofer-Gesellschaft brochure)
- ² Fraunhofer International: Advancing a Worldwide Partnership in Research and Development (Fraunhofer-Gesellschaft brochure)
- ³ Fraunhofer-Gesellschaft unpublished presentation material
- ⁴ Fraunhofer-Gesellschaft unpublished presentation material
- ⁵ In addition, some 4-12 percent of revenues are derived from other income sources, such as licensing of patents and building investments.
- ⁶ Technology Transfer Systems in the United States and Germany: Lessons and Perspectives (National Academy Press, Washington, D.C., 1997)
- ⁷ Fraunhofer International: Advancing a Worldwide Partnership in Research and Development (Fraunhofer-Gesellschaft brochure)
- ⁸ Fraunhofer International: Advancing a Worldwide Partnership in Research and Development (Fraunhofer-Gesellschaft brochure)
- ⁹ Fraunhofer International: Advancing a Worldwide Partnership in Research and Development (Fraunhofer-Gesellschaft brochure)
- ¹⁰ Chemical and Engineering (April 21, 1997)
- ¹¹ The Research Establishments: Addresses and Research Fields (Fraunhofer-Gesellschaft brochure)
- ¹² Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)
- ¹³ Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)
- ¹⁴ Fraunhofer International: Advancing a Worldwide Partnership in Research and Development (Fraunhofer-Gesellschaft brochure)
- ¹⁵ Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)
- ¹⁶ Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)
- ¹⁷ The German government recently commissioned the Fraunhofer Institute for Systems Technology and Innovations Research (ISI) to undertake a comprehensive study of technology at the threshold of the 21st century. This study identified 87 technologies that are providing focus to both Fraunhofer research and Government initiatives.
- ¹⁸ Annual Report 1995 (Fraunhofer-Gesellschaft)
- ¹⁹ Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)
- ²⁰ Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)

Part 3

THE FRAUNHOFER SOCIETY GOES INTERNATIONAL

3.1. Globalization Strategy

From its founding in 1949 through to 1992, the Fraunhofer Society was largely confined to Germany. Starting in the 1992-1993 period, with the German recession causing deep cuts in industrial funding and the costs of German reunification constraining resources for government project and basic funding, there has been a movement to expand operations outside of Germany. This was accelerated by the recognition that 85 percent of the world market for state-of-the-art technology is generated and produced outside Germany. Greater participation in the global innovation system is critical if the Fraunhofer Society is to pursue research at the cutting edge and develop competitive offers for contract research¹. It is also recognized by the Fraunhofer Society that a greater global presence helps to promote Germany as a commercial and industrial location².

Specifically, the Fraunhofer Society's globalization strategy, coming after 40 years of concentrating on the German market, is responding to the following developments:

3.1.I. New Markets

The economic situation in Germany has changed substantially in the last five years and the Federal Government has curtailed its funding largess. Federal and local funding on all levels is more difficult to obtain and competition among State agencies and institutions is intense. These funding cutbacks in R&D in recent years have resulted in a situation where the Fraunhofer Society's research expertise is greater than the needs of the German market. In order to maintain, if not grow this expertise, the Fraunhofer Society is looking to new markets outside Germany.

3.1.II. More Intense Competition

As noted in recent annual reports, the Fraunhofer Society perceives itself to be at a competitive disadvantage due to "relatively low level of base funding." According to the Fraunhofer Society, other public institutes, notably universities, can make more cost-effective offers for government and industry projects. To improve its competitiveness,

"Federal and local funding on all levels is more difficult to obtain and competition among State agencies and institutions is intense."

“...international locations is seen as adding value to the German base of knowledge through greater sources for the transfer of technology.”

the Fraunhofer Society is trying to increase its base funding by going abroad.

3.1.III. International Networking

The Fraunhofer Society aspires to expand its global procurement of know-how. Approximately 85 percent of the world market for state-of-the-art technology is generated and produced outside Germany. The same is true for patents. To maintain its competitiveness in the field of contract research and to pursue research on the cutting edge, the Fraunhofer Society seeks to network with the international scientific community.

The President of the Fraunhofer Society, Hans-Jurgen Warnecke, has championed the globalization strategy as the mark he will make on the organization³. With the battles for government funding ensuing, Warnecke set the goal of expanding operations internationally, thereby increasing the value of the Fraunhofer Society's research not only in the volume of contracts but in the greater variety of sources of knowledge. In essence, Warnecke's move to international locations is seen as adding value to the German base of knowledge through greater sources for the transfer of technology.

3.1.IV. Multinational Customer Requirements

With the globalization of industry, suppliers are increasingly under pressure to locate close to their major customers. The Fraunhofer Society, being a supplier of research expertise, is similarly under pressure to provide its services where its multinational clients, such as automotive firms, conduct their work. In addition, many of the Fraunhofer Society's traditional domestic clients are also becoming multinational. In the last few years, German companies have relocated more of their manufacturing and R&D overseas, especially in the United States.

Given these trends, the market for contract research has changed significantly over the past decade – competition has intensified and new requirements have arisen. In its annual reports, the Fraunhofer Society describes these new requirements as including:

- The internationalization of market, production, and research and development activities, as well as the increasing independence of manufacturing locations from levels of training, due to the ever greater implementation of production integrated intelligence.

- A shortening of product life-cycle, as well as fluctuating and more greatly differentiated demand calling for more rapid responses to the market and low production costs without detriment to top quality.
- The introduction and implementation of new models of corporate organization.
- Concentration of in-house R&D on key fields, such as favor the global procurement of know-how and technology.
- Increasing importance attached to systems solutions, involving multi-disciplinary approaches increasing integration and interdependence between application oriented basic research, industrial research and product development, calling for still closer collaboration between industry and publicly funded R&D establishments.
- A shift in the creation of added value from manufacturing to service sector.

3.1.V. Technology Acquisition

While Germany is a global leader in a number of industries, such as machine tools and dies, and fine chemicals, it lags behind in other industries that are playing an important part in the global economy, such as information technology, computer graphics, and biotechnology. By extending its resources overseas, the Fraunhofer Society can both better advance the interests of its strong industries, as well as gain insight into how to strengthen those industries where Germany is relatively weak. For example, the 1996 Annual Report makes the following observation about the Fraunhofer's Michigan Resource Center: "The resultant flow of know-how back to the parent Institute, the Fraunhofer Institute for Laser Technology ILT in Aachen, can now be exploited fully to the benefit of the German industry."

To support the technology promotion and acquisition efforts of individual Fraunhofer Institutes in the United States, the Fraunhofer Society has considered establishing an Office of Technology Deployment (OTP) and Global Manufacturing Initiative (GMI). The OTP, which at one time was to be located at the Fraunhofer Resource Center in Boston, would coordinate the effort to make the technologies of the Fraunhofer Society in Germany available to industry in the United States. Among the services of the GMI, which similarly was to be located at the Fraunhofer Resource Center in Boston, would be to facilitate communication between the Fraunhofer Society in Germany and the United States and to provide manufacturing relocation consulting services.

"By extending its resources overseas, the Fraunhofer Society can both better advance the interests of its strong industries, as well as gain insight into how to strengthen those industries where Germany is relatively weak."

Given these technology promotion and acquisition considerations, the U.S.-based Fraunhofer operations can be classified as follows:

TABLE II: Technology Promotion and Acquisition of Fraunhofer U.S. Operations		
Primary Focus	Area of Expertise	U.S.-Based Operations
Technology Promotion	machine tools & dies material processing & manufacturing medical/diagnostic equipment	FRC-Massachusetts FRC-Michigan FRC-Delaware FTF-Hialeah
Technology Acquisition	information technology computer graphics laser processing	FC-Maryland FCR-Rhode Island FRC-Michigan

3.1.VI. International Funding

Many European governments are shifting a portion of their research funds to programs managed by the European Commission (EC). This includes small- to medium-sized projects in applied science. This new funding environment represents both opportunities and challenges for the Fraunhofer Institutes.

The shifting of German funding to the EC intensifies the competitive environment within which the Fraunhofer Institutes have to operate. Inside Germany, each Fraunhofer Institute has a fairly unique, well-defined mission that is often denied to other Institutes. They also have a well developed customer base and a network of ex-Fraunhofer employees in key industry and government positions. However, in the context of the European arena, the Fraunhofer Institutes have to compete in a much more competitive, wide open, and less segmented market.

In addition, many European programs try to promote networking in Europe and require the participation of more than one Institute or company in a project, preferably from different European countries. This implies more sharing of research ECUs. However, EC research funding is based on cost-sharing contracts. Normally the Community

financial participation will not exceed 50 percent of the total expenditure of the project. The traditional Fraunhofer Model, however, requires 100 percent funding.

3.1.VII. Greater Scope for Research Abroad

Inside Germany, with the prominence of the Green Party and many environmental-based interest groups, there is strong opposition to some of the new frontiers of science. Many elements of German industry have become impatient with the situation – large chemical and biological companies are relocating their research activities to subsidiaries in other countries where resistance is less visible. Similarly, the Fraunhofer Society is finding that countries such as the United States offer research opportunities that are increasingly difficult to duplicate in Germany.

3.2. International Expansion Objectives

The Fraunhofer's international objectives are stated in the 1995 Annual Report as follows:

An essential premise of all activity abroad is concrete benefit for the German Fraunhofer-Gesellschaft or Germany as a whole. The research establishments abroad are thus always directly associated with one of the Fraunhofer Institutes, which is responsible for ensuring a balance between benefit and risk.

In elaboration, the 1995 Annual Report specifies the following objectives of Fraunhofer Institutes' branches abroad:

- I. Increased Expertise:
 - Joint activities with top foreign R&D establishments.
 - Additional know-how through contract research in foreign markets.
 - Collaboration in technological initiatives in the host countries.
- II. Expansion of Business Foundations:
 - Extending the technological spectrum and customer base.
 - Maintaining existing customer relations when production facilities are relocated abroad.
 - Feedback to facilitate innovative preliminary research.

“Inside Germany, with the prominence of the Green Party and many environmental-based interest groups, there is strong opposition to some of the new frontiers of science.”

III. Qualification of staff:

- Identification and recruitment of top foreign scientists.
- Further training and motivation of staff.

IV. Benefits to the Economy:

- Exploitation of advanced foreign technology within German contract research.
- Stimulation of exports of German investment goods in connection with contract research on behalf of foreign countries.
- Promoter of the German R&D infrastructure abroad.
- Promotion of Germany as an industrial location among foreign investors.

To achieve these objectives, the 1996 Annual Report States that the Fraunhofer Society pursues a number of different modes of international cooperation:

- Scientific exchange and collaboration with other institutes and universities.
- Participation in international initiatives.
- Market research and reconnaissance project teams abroad.
- Liaison or representative offices.
- Competence centers.

3.3. Fraunhofer in Asia

The Fraunhofer Society is moving more slowly in Asia than it is in the United States (see following chapter). To date, only representative offices have been established. These are located in Kuala Lumpur, Malaysia, and Singapore with plans for future offices in Jakarta, Indonesia, as well as in Beijing, China. The stated objective of these offices is to support Asian companies and corporations interested in technology transfer, as well as German and multinational companies already active or planning operations in the region. While its Asian base is modest, the Fraunhofer Society has successfully completed projects in Indonesia, Malaysia, Singapore, China, Thailand and Korea, covering research in the areas of human resource development, technology transfer, and factory automation and assembly. The Fraunhofer Institute for Manufacturing Engineering and Automation (IPA-Stuttgart) manages the Asian representative offices⁴.

“The Fraunhofer Society is moving more slowly in Asia than it is in the United States.”

3.4. End Notes

¹ Annual Report 1995 (Fraunhofer-Gesellschaft)

² Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)

³ See the remarks of the Hans-Jurgen Warnecke, President of the Fraunhofer-Gesellschaft in the Preface to the 1995 and 1995 Annual Reports (Fraunhofer-Gesellschaft)

⁴ The 1996 Fraunhofer Annual Report summarizes the different focus of the representative offices in South-East Asia as: “Long-term objectives are colored by the realization that the key to success in Asia is not just know-how but more particularly “know-who”.

Part 4

THE FRAUNHOFER SOCIETY COMES TO AMERICA

4.1. The American Market for Contract Research

In coming to America, the Fraunhofer Society is seeking to market its services to U.S. small- and medium-sized companies, as well as build upon its links to large corporations and establish a base for pursuing government contracts. With its open and robust economy, the American market offers the Fraunhofer Society, as it does other research organizations, the world's largest market for contract research.

Manufacturing employs almost 19 million Americans, representing more than 20 percent of the private sector workforce and accounting for almost a fifth of the U.S. gross national product over the past 40 years. Some 381,000 small manufacturing establishments (more than 98 percent of all manufacturing), employ fewer than 500 employees per firm. These smaller manufacturing establishments contribute greater than half of the total U.S. value-added (54.5 percent) in manufacturing and employ almost two-thirds of all manufacturing employees – approximately 12 million Americans. Smaller firms, as well, supply many of the component parts needed by large firms.

An estimated 70 percent of U.S. small manufacturers are unable to adopt modern manufacturing equipment or practices and face various barriers to change. This may be due to a simple lack of awareness of changing technology, production techniques, and business management practices. It is also difficult for owners and managers of small companies to find high-quality, unbiased information, advice, and assistance.

4.2. Fraunhofer USA's Mission

The mission of the Fraunhofer in the United States is described in the Fraunhofer USA homepage as follows:

The promotion of the technical competence of U.S. manufacturing industry through technology development, technology deployment, and new modes of training and education in engineering¹.

“With its open and robust economy, the American market offers the Fraunhofer Society, as it does other research organizations, the world’s largest market for contract research.”

The Fraunhofer USA relationship with Germany is also described as follows:

Fraunhofer USA is an independent organization which is an affiliate of the Fraunhofer-Gesellschaft.

At the same time, the 1995 Fraunhofer-Gesellschaft Annual Report states that the objective of the Fraunhofer Institutes in the United States is to “establish a foothold in the American market” and “achieve concrete benefits for their parent establishments” in Germany².

4.3. Fraunhofer U.S. Tax Status

Fraunhofer USA, based in Ann Arbor, Michigan, is a not-for-profit, tax-exempt 501(c)(3) corporation. It is the American subsidiary of the Fraunhofer-Gesellschaft, Munich, Germany and was founded in 1994. Its stated mission is to enhance the technological competence of the U.S. manufacturing industry by fostering technology development and deployment, and by innovating new modes of training and education in engineering. To this end, it seeks to combine the strengths of industry, university, and government. Through such cooperation, Fraunhofer USA strives to increase the competitiveness of manufacturing companies and to assist with technical problems in the short term, and to positively impact regional economies in the long term.

The Fraunhofer Center for Research in Computer Graphics, located in Providence, Rhode Island, is a separate not-for-profit organization. It is not under the Fraunhofer USA umbrella.

4.4. Fraunhofer USA General Activities

Fraunhofer USA is currently active in Massachusetts, Michigan, Florida, Delaware, and Maryland. The various establishments in these States have been set up to function more like branch offices of their respective Fraunhofer Institute parents in Germany, than as full partners. The projects that they undertake reflect the boundaries of each Institutes' technology mandate. In addition, their U.S. location attempts to optimize the industry needs and capabilities of the surrounding area's regional economy with the interests of the German-based Fraunhofer sponsor.

“...their U.S. location attempts to optimize the industry needs and capabilities of the surrounding area's regional economy with the interests of the German-based Fraunhofer sponsor.”

The range of Fraunhofer USA organizational forms can be described as follows:

4.4.I. Headquarters: Fraunhofer USA

Fraunhofer USA is the American-based subsidiary of the Fraunhofer-Gesellschaft based in Munich. The principal office is located in Ann Arbor, Michigan. Fraunhofer USA operates the various resource centers, technology centers and university research centers that are being established in the United States.

4.4.II. Fraunhofer Resource Centers (FRC)

Fraunhofer USA has established Fraunhofer Resource Centers (FRC) in Massachusetts, Michigan, and Delaware, with at least one more in the planning stages for Pennsylvania. Their objective is to provide technology development and deployment to targeted industrial and public sector clients by linking application-oriented basic research to the solution of real world problems. This can involve products and process solutions for both SMEs and large enterprises, as well as troubleshooting and training in new equipment and innovative processes. Each FRC strives to be able to offer state-of-the-art manufacturing facilities staffed with highly experienced personnel and the latest high-tech equipment operating under production conditions. To maximize resources and to pool the costs, each FRC also seeks to work with national laboratories, universities, engineering schools, and consortia-led efforts.

4.4.III. Fraunhofer Centers for Research

Fraunhofer USA has established a Fraunhofer Center for Research in Rhode Island and College Park, Maryland. The FCR specializes in precompetitive research, as opposed to the FRCs that specialize in solving real world industrial problems.

4.4.IV. Fraunhofer Teaching Factories

Fraunhofer USA is assisting in the establishment of a Fraunhofer Teaching Factory (FTF) in Florida. The services of a teaching factory are more limited than those of either FRC or FCR because they concentrate on technology deployment, training, and education.

“Each FRC strives to be able to offer state-of-the-art manufacturing facilities staffed with highly experienced personnel and the latest high-tech equipment operating under production conditions.”

4.V. Technology Support Services to Fraunhofer U.S. Network

To support the technology promotion and acquisition efforts of the various U.S.-based Fraunhofer establishments, Fraunhofer USA has been reviewing the establishment of two central offices: the Office of Technology Deployment and the Global Manufacturing Initiative. These central offices, if ever established, would facilitate efforts to promote German technologies and manufacturing opportunities to U.S. industry.

**TABLE III:
THE FRAUNHOFER USA ORGANIZATION**

Type of Establishment	Location	Activity
Headquarters (Fraunhofer USA)	Ann Arbor, MI	Strategic direction for U.S.-based Fraunhofer establishments.
Resource Centers	Boston, MA Ann Arbor, MI Newark, DE + Planning Stages: Pennsylvania	In partnership with local State and universities, provides technology development & deployment to targeted industrial and public sector clients.
Centers for Research	Providence, RI College Park, MD	Targeted precompetitive research.
Teaching Factories	Hialeah, FL	Targeted technology deployment and training and education.
Technology Support Services (under review - not established)	Office of Technology Deployment (Boston) Global Manufacturing Initiative (Boston)	Facilitate efforts to promote German technologies and manufacturing opportunities to U.S. industry.

4.5. The Fraunhofer USA Network

Fraunhofer USA currently operates three resource centers (with at least one more in the planning stages), two centers for research, and one teaching factory³.

4.5.I. Fraunhofer Resource Center - Massachusetts (FRC-MA)

The Fraunhofer Resource Center - Massachusetts is affiliated with Boston University and located on the campus. It has a staff of 25 employees and is a branch of the Fraunhofer Institute for Production Technology (FhG-IPT) in Aachen, Germany. Its focus is developing business with original equipment manufacturers (OEM) metal products companies. Activities are dedicated to production technology, such as tool and die manufacturing, rapid prototyping/tooling, forming technologies, and production planning. Key technologies promoted by the Center are high performance milling, stereolithography, EDM, and CAD/CAM.

FRC-MA activities take place at Boston University's new \$10 million, 10,000-square foot facility called the Production Technology Collaboration. This facility, while wholly financed by Boston University, is home to engineers, researchers and equipment from the university, the Fraunhofer, and private commercial companies. Fraunhofer's affiliation with Boston University is based on a cooperative agreement signed in 1994. With the demise of the Fort Devens plan (discussed below), a more complex agreement is in the process of negotiation. In the future it is expected that the two organizations will conduct joint marketing and contract research. In a separate effort, Boston University, in cooperation with the FRC-MA, is expanding its school of engineering.

Specific areas of research and service undertaken by FRC-MA include:

- EDEM-EDM Center with Integrated Electrode Machining
- Laser Assisted Machining
- High Performance Milling
- Rapid Prototyping
- Global Manufacturing Initiative
- Technology Calendar
- Quality Management

“Activities are dedicated to production technology, such as, tool and die manufacturing, rapid prototyping/tooling, forming technologies, and production planning.”

“The Massachusetts Center is working with a variety of U.S. companies. It has had contracts with Polaroid, General Electric, Agfa, Chrysler, Ford, Boeing...”

“FRC-MI provides technical and personnel resources in collaboration with universities and industry to develop current and future products and/or processes to enhance manufacturing technologies.”

The Massachusetts Center is working with a variety of U.S. companies. It has had contracts with Polaroid, General Electric, Agfa, Chrysler, Ford, Boeing, and a variety of smaller companies.

Fraunhofer USA had contemplated plans to create a stand-alone Fraunhofer Institute at Fort Devens, 35 miles northwest of Boston. This would have required an investment of \$16 million, only \$2.25 million of which would be supplied by the Commonwealth of Massachusetts. The Center would have housed a state-of-the-art machining and injection molding complex and work with manufacturers to improve production technologies. Plans for the Institute have been put aside for the time being due to the size of the investment, the 10 year commitment involved, and the belief that the market could not support two large applied research centers given that Boston University's Production Technology Collaboration was already up and running (with the help of Fraunhofer professionals).

4.5.II. Fraunhofer Resource Center - Michigan (FRC-MI)

The Fraunhofer Resource Center-Michigan (FRC-MI) in Ann Arbor is affiliated with the University of Michigan, College of Engineering, and is focused on the Michigan automotive industry. It works in close association with the German Fraunhofer Institute for Laser Technology (FhG-ILT) in Aachen and the Fraunhofer Institute for Material Science and Surface Engineering (FhG-IWS) in Dresden. FRC-MI provides technical and personnel resources in collaboration with universities and industry to develop current and future products and/or processes to enhance manufacturing technologies. Besides the industrial community, the University of Michigan and the State of Michigan have initiated and are supporting FRC-MI activities. The State of Michigan provided \$2.25 million in basic funding over the first three year time period. In addition, the FRC-MI offers training and apprenticeship programs.

FRC-MI's activities are primarily dedicated to laser material processing, specifically welding, soldering, brazing, cutting and surface treatment, as well as advanced coating technologies. Equipment includes CO₂ lasers, Nd:YAG lasers and laser diodes (HPLDs) in the power range of 0,4 kW-12 kW, and pulse plasma machinery. FRC-MI promotes its provision of complete solutions up to the development and/or fabrication of prototype production systems in three main areas:

1. Direct material processing with high-power laser diodes (HPLD).
2. Welding and cutting with high power CO₂ and Nd:YAG laser.
3. Improvement of wear resistance for various material surfaces.

In addition to its activities in laser materials processing, FRC-MI has established two more divisions, one for forming technology and one for thin film technology. The Forming Technology Division focuses on sheet metal forming and tube hydroforming. The Thin Film Division predominantly works on physical vapor deposition (PVD) technology. All activities are intended to aid customers in reducing manufacturing costs and improving product quality.

The investment in equipment in Ann Arbor is approximately \$5 million. Within 6 months of setting up in Ann Arbor, the laboratory had received contracts for 15 projects from companies of a variety of sizes, most notably Ford Motor Company (which already has a close relationship with the Fraunhofer Society in Germany, especially in Aachen).

4.5.III. Fraunhofer Resource Center - Delaware (FRC-DE)

The University of Delaware, College of Engineering, secured funding from the State of Delaware and the Fraunhofer Society for the establishment of a Fraunhofer Resource Center in late 1996. This Center, which is being established at the Delaware Technology Park in Newark, Delaware, will serve as a technology development laboratory for industry (principally metal manufacturing companies). To this end, it will draw upon its links to the Fraunhofer Institute for Applied Materials in Bremen, Germany.

The immediate focus of the Delaware Resource Center is on improving metal manufacturing process techniques through technology development and deployment of near-net-shape manufacturing technologies, rapid prototyping, process simulation, lightweight construction, and polymer process and bonding technologies. Equipment includes metal-foaming technologies, computer simulation workstations, and rapid prototyping equipment for metal parts. For training courses and deployment, the FRC-DE collaborates with the Delaware Technical and Community College and the Delaware Manufacturing Alliance.

“The stated goal of the FCRCG is to be the leading group for advanced research and development in visually oriented and interactive processes, services, and applications that facilitate international collaboration...”

4.5.IV. Fraunhofer Resource Center - California

A Fraunhofer Resource Center, or at least a series of projects at the University of Southern California, has been given some consideration. There is no information available about time frame or possible focus of the activities.

4.5.V. Fraunhofer Resource Center - Pittsburgh

Pittsburgh-based institutions, led by the University of Pittsburgh, have been pursuing the establishment of a Fraunhofer Resource Center as part of “Pittsburgh’s drive for international presence and awareness.”⁴ Specific plans have yet to be announced.

4.5.VI. Fraunhofer Center for Research in Computer Graphics, Providence, Rhode Island

The Fraunhofer Center for Research in Computer Graphics, Inc. (FCRCG), located in Providence, RI, began operations in early 1994. It is a computer graphics research group specializing in pre-competitive research in the areas of volume visualization, virtual environments, collaborative work tools, and user interface design. FCRCG has a cooperative agreement with Brown University and is part of the Fraunhofer Institute for Computer Graphics Research in Darmstadt, Germany.

The stated goal of the FCRCG is to be the leading group for advanced research and development in visually-oriented and interactive processes, services, and applications that facilitate international collaboration over high speed global networks for business, scientific, and educational purposes that better the lives of individuals and society worldwide. To meet this goal, it is pursuing R&D in three areas:

1. Health care, research into better user interfaces, design of multimedia, databases, multimedia mail, and collaborative work paradigms for experts should lead to more cost-effective solutions to providing quality health care at an affordable cost to more people worldwide. Telemedicine is a particular focus, with FCRCG’s technology being successfully deployed by the U.S. military in Bosnia.
2. Environmental topics.
3. Industrial competitiveness.

FCRCG is also concentrating on continuing education that has an international, multinational, multicultural focus. It plans to build on its expertise in tools, services, and applications for teacher-student collaboration over high-speed global networks. Connections with universities in the United States (Brown University, Georgia Institute of Technology, University of Southern California), and in Europe (Germany and Portugal) will be drawn upon to demonstrate pilot educational scenarios.

FCRCG seeks four main sources of financial support:

1. Industrial research contracts from private industry in the United States and from Europe to prepare studies, to perform analysis, and to develop innovative new user-interfaces and application prototypes.
2. Grants and donations from private corporations and non-profit foundations that sponsor research into the development of new algorithms, standard interchange formats, user-interface methodologies, and distributed applications that relate to computer graphics imaging.
3. Grants and contracts from public agencies (local, State, and Federal) will be sought under a variety of public programs.
4. Fees for operating and administering consortia that promote international technical activity consistent with the scientific and educational mission of the FCRCG will be sought. As a vendor-neutral, non-profit organization with significant connections to R&D centers worldwide, FCRCG is in a unique position to organize consortia that bring together the interests of the United States, Europe, and South America for the purpose of scientific and technical interchange, for operating and evaluating demonstration projects, and for disseminating in a public and open fashion the results of its research and the research of its members.

The FCRCG has contracts with Hewlett Packard and a number of unspecified Japanese, German, Australian, Swedish, and Portuguese companies. The FCRCG is also interested in public contracts and continues to pursue National Science Foundation grants and is presently doing projects for the Defense Advanced Research Projects Agency (DARPA).

“FCRCG is also concentrating on continuing education that has an international, multinational, multicultural focus.”

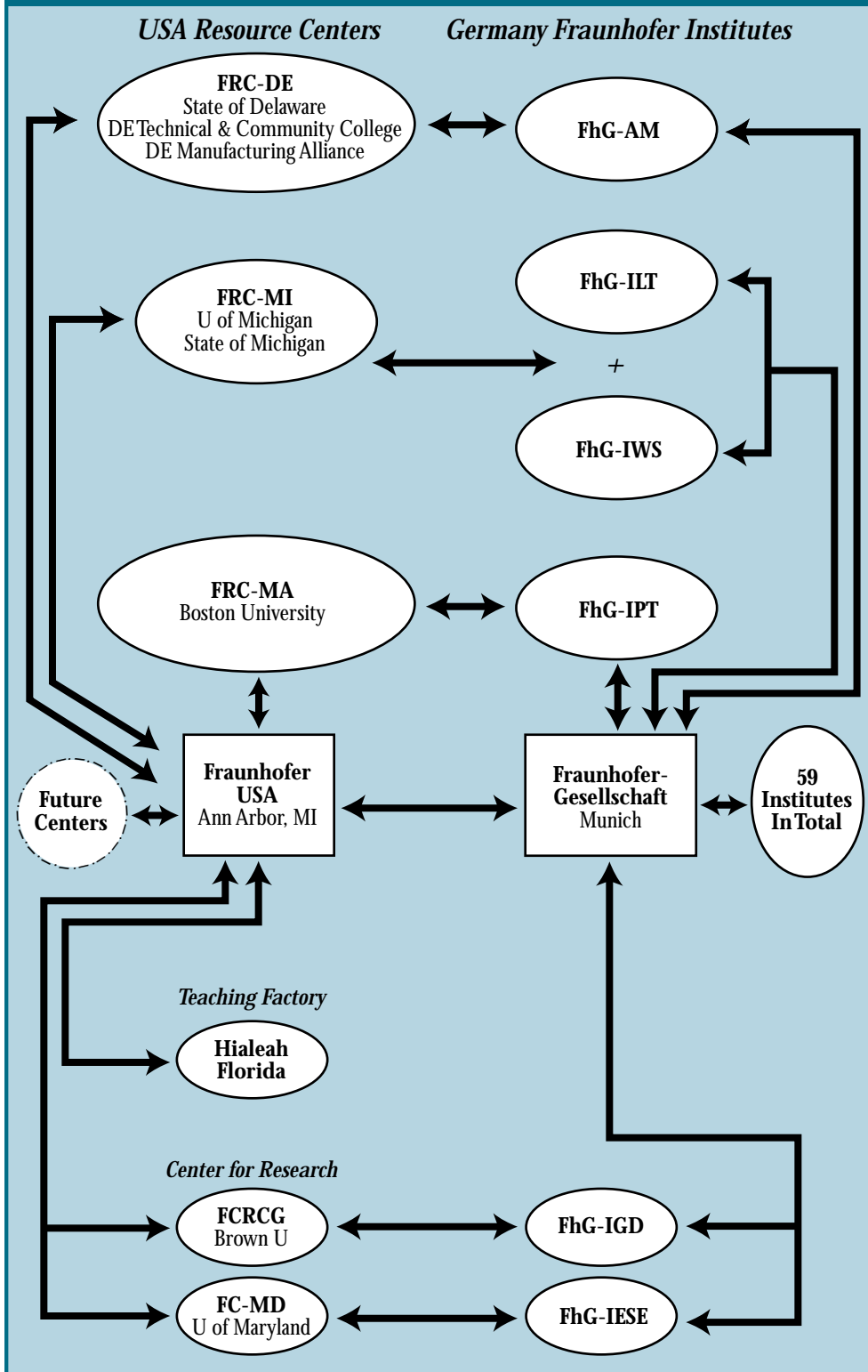
4.5.VII. Fraunhofer Center - Maryland

The Fraunhofer Center - Maryland (FC-MD) opened in College Park, Maryland, in February 1998⁵. Partnering with the University of Maryland and its Institute for Advanced Computer Studies and the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslauten, Germany, FC-MD will focus on software development practices and software competence as well as process and product improvement. Envisioning itself as an “experience factory,” dedicated to improving commitment in the applications division and the development of software with complex engineering competence, FC-MD’s objective is to become a hub for multinational industry and smaller regional companies in the Washington, D.C. area.

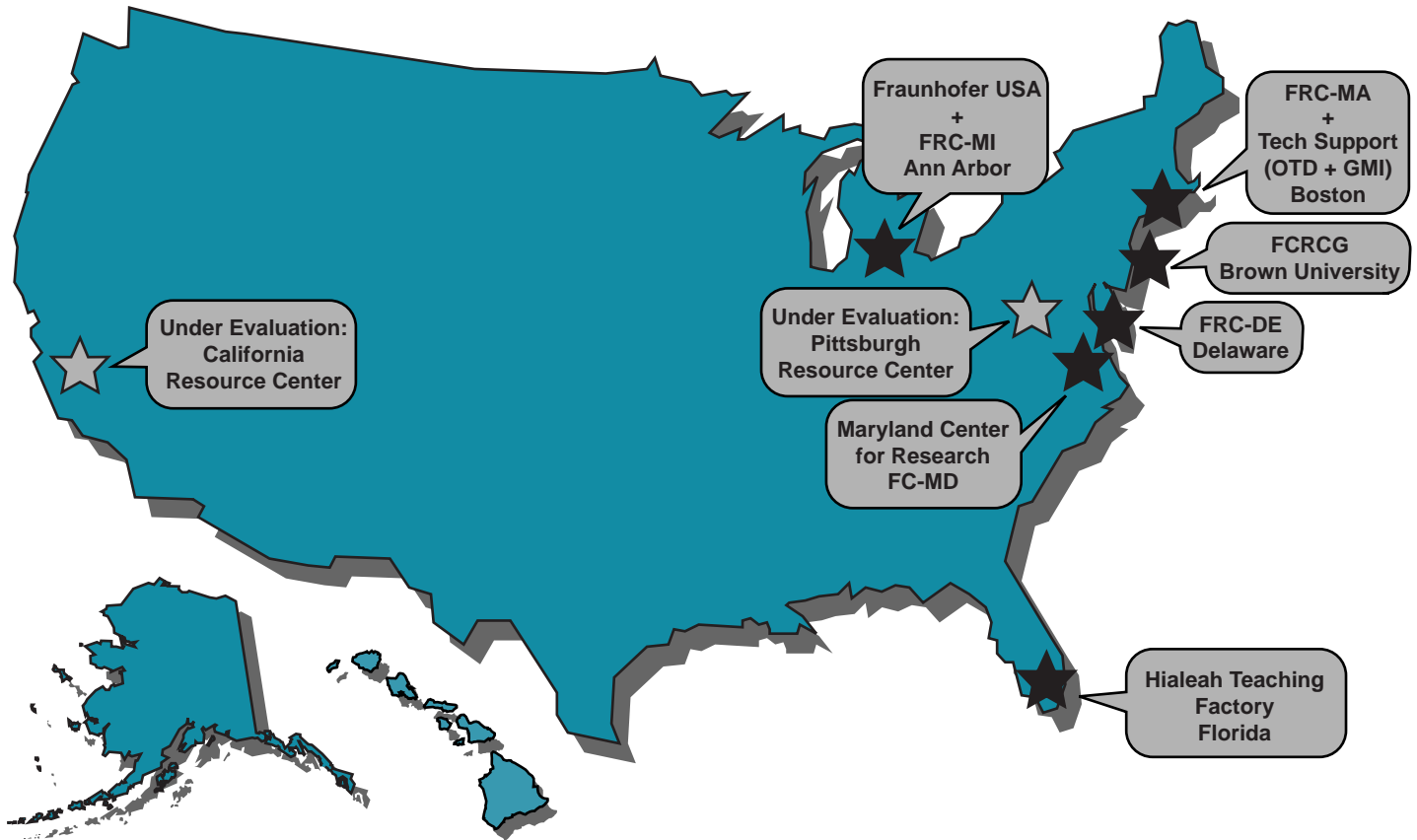
4.5.VIII. Fraunhofer Teaching Factory: Hialeah

Fraunhofer USA is assisting in the founding of a teaching factory in Hialeah, Florida. Technologies related to medical and diagnostic equipment and packaging, among others, are being targeted. The former Coulter Electronics building has been donated to the city and is being completely retrofitted to meet the demands of this new high-tech facility. Fraunhofer USA is working in conjunction with “Team Miami,” a Beacon Council Initiative to foster economic development which includes the University of Miami and Florida International University. Fraunhofer USA has received a grant from the city of Hialeah to undertake a one-year technology assessment of local industry.

ILLUSTRATION III: THE FRAUNHOFER USA NETWORK



The Growing Fraunhofer USA Network



4.6. End Notes

¹ Fraunhofer USA, Homepage (<http://www.fraunhofer.org>)

² Annual Report 1995 (Fraunhofer-Gesellschaft)

³ Fraunhofer USA will also operate the planned center(s) in Canada.

⁴ Germany's Focus on Pittsburgh Tomorrow's Visit by Germany's President Shows an International Link That's Working (Pittsburgh Post - Gazette, May 16, 1997)

⁵ Fraunhofer News, Fraunhofer USA, Inc. (Vol. 4. Winter 1997/'98)

Part 5

THE U.S. INNOVATION SYSTEM AND THE FRAUNHOFER SOCIETY

The intensifying pressure of global market competition makes it unlikely that there will be any large-scale return to great corporate research laboratories. Facilities like the Bell Labs, where fundamental science was developed and united with enormous engineering resources to produce technologies like the transistor and the laser, have become too great a cost for most companies to carry¹. Businesses around the world and of all sizes, accordingly, are increasing their R&D efforts on “quick pay-back, lower risk” projects.

By coming to America, the Fraunhofer Society is seeking to fill this gap in the U.S. innovation process. With its reputation in Germany of being able to partner government and university resources for applied and application oriented basic research, the Fraunhofer is marketing itself to State governments and universities as the answer to their innovation strategies.

At the same time, American industry has always looked to the source that is able to solve its problems the fastest, with the highest quality and the fewest problems. The globalization of industry makes this even more imperative. As it builds its base of State and university partners, the Fraunhofer Society is also developing its U.S. client base by stressing its factory experienced researchers, state-of-the-art equipment, and understanding of the problems and constraints faced by industry.

The full extent of the impact of the Fraunhofer Society on the U.S. innovation system will not be known for some time because most of the establishments are still in the early stages of establishing their presence. At this point, though, it can be observed that the Fraunhofer Society brings the following to its partnership with American universities and industry:

- Researchers and leaders who are able to bridge the gap between theory and application.
- Teaching and apprenticeship programs.
- The Fraunhofer Society infrastructure in Germany.
- At-cost, world-class applied research and consulting.

“By coming to America, the Fraunhofer Society is seeking to fill this gap in the U.S. innovation process.”

In return, the Fraunhofer Society receives:

- New markets for contract research.
- Exposure to U.S. and international techniques and innovations.
- Potential entry into U.S. markets for German suppliers associated with the Fraunhofer Society.
- The cycles of development that make up the process of solving a problem or developing a new product for a company (i.e., where the American company may have their problem solved, it is the Fraunhofer Society that retains the knowledge of how to solve the problem).

5.1. Preliminary Observations: Key Elements of Success

Among the advantages which are helping the Fraunhofer Society to establish its presence in the U.S. innovation system are:

5.1.I. Government Funding Linked to Market Orientation

Within the Fraunhofer Model, government funding is directly linked to the extent that industrial and public needs are addressed. In keeping with the “matching funding” formula, government (or basic) funding grows if the revenue from industry and public contracts is also growing. In contrast to some U.S. programs which “sunset” government funding as industry participation grows, the Fraunhofer Model rewards market orientation with increased public investments in the technology transfer capabilities of the organization. This, in turn, better positions the Fraunhofer Society to seek further industrial and public contracts.

5.1.II. Bridging Academic and Industrial Research

Each Fraunhofer Institute offers an environment where academic and industrial scientists can work together to explore applied research opportunities. This is achieved by locating near universities, jointly appointing a full professor as director of a Fraunhofer Institute and to a university chair, and employing Ph.D. candidates to work on applied research projects². This encourages a two-way flow of knowledge: the Fraunhofer Society can draw upon basic research funded by institutional funds of the university, and the university is exposed to applied research needs, particularly that of the local economy.

What is unique about the Fraunhofer Model is that the Ph.D. students employed by Fraunhofer Institutes are trained at the technology

“Government funding is directly linked to the extent that industrial and public needs are addressed.”

transfer interface. They complete their five year work/training sessions with their respective Institute knowing how to develop an extensive network of business contacts, market the resources of the Fraunhofer Society or similar organization, and manage all phases of any particular project. In short, the training is broad enough so that the student/workers can readily adapt from one field to another, while offering skills in communications, teamwork, and multidisciplinary tasks. At the same time, this entrepreneurial behavior of the science/engineering doctoral candidates enables the Fraunhofer Society to maintain high standards of technological competence, in addition to that of scientific competence.

5.1.III. Focus on Technology Transfer Needs of Both Small and Large Companies

The Fraunhofer Model seeks to meet the technology transfer needs of both small- and medium-sized companies (SMEs) as well as large enterprises. This is done by providing a range of R&D activity including:

- Curiosity-oriented basic research.
- Application-oriented industrial basic research.
- Development of key technologies.
- Applied research.
- Development (products, processes, methods).
- Prototypes.
- Pilot installation models.
- Optimization to series production.

SMEs tend to use the range up to prototyping, whereas large companies concentrate on basic and long-term strategic research³. Federal, State, and university technology initiatives that focus on either SMEs or large enterprises might benefit from examining how the Fraunhofer Society manages to integrate both technology diffusion and “pathbreaking” R&D.

5.1.IV. Leveraging Economic Development

The Fraunhofer Model requires that local governments contribute funds to support the Institutes located in their jurisdiction. From the local government’s perspective, their Fraunhofer partner is usually seen as an attractive investment due to the tax benefits, employment and stimulus to regional business and industry that can result.

“The Fraunhofer Society has a decentralized structure that emphasizes autonomy of the individual Institutes.”

The limited experience of the Fraunhofer Society in the United States shows that this component of the Model can be transferable. The Fraunhofer research center affiliated with Brown University, for instance, is active in bolstering Rhode Island’s economic development by attracting more high-tech companies to the State.

5.1.V. Technology Transfer Organized Around Centers of Excellence

Each Fraunhofer Institute has a well-defined area of research and is prevented from working outside of that area. The resulting institutional memory and concentration of resources and in-depth knowledge has been a major source of the Fraunhofer Society’s strength.

5.1.VI. Decentralized Structure but One Set of Technology Transfer Rules

The Fraunhofer Society has a decentralized structure that emphasizes autonomy of the individual Institutes. At the same time, the 59 Institutes and related organizations that make up the Fraunhofer Society in Germany operate as one organization with uniform rules and contracts and well-defined deliverables and research methodology. These organizational characteristics have resulted in “flexible adaptation to the needs of the research market” while rigorously maintaining standards and value-added⁴.

5.2. Preliminary Observations: Possible Long Term Disadvantages

While the Fraunhofer Model offers many advantages, it is also important to recognize that it too has its limitations. Some of these may become more apparent as the Fraunhofer Society’s presence in the United States grows. Among the potential disadvantages that may become more apparent over time are:

5.2.I. Dependence on German Know-How and Equipment

The fact that the Fraunhofer Society will own the “cycles of development” for the problems they solve for U.S. industry may in the long term prove to be a competitive challenge to U.S. industry. Industrial restructuring in the United States has resulted in many manufacturers outsourcing for their research, parts and services

needs. One key example is the automotive industry which for some time has been passing down to suppliers the costs of the research and development effort. With an increased Fraunhofer Society presence in the United States, more and more of these suppliers will be turning to the services of organizations like the Fraunhofer Society in order to develop their technology. As this role continues to grow for the Fraunhofer Society, the degree of dependency on German know-how could become an issue.

There is also the potential for dependence on German machines, tools and techniques. The Fraunhofer Society is providing U.S. universities with German equipment, training, and apprenticeship programs, all of which are also available to U.S. industry. In its teaching factories, it is training American workers on German machines with German techniques. In its Office of Technology Deployment, if established, it would provide German technology, and the training to use that technology to any company.

5.2.II. Focus on German Technology and Investment Interests

As stated in various Fraunhofer annual reports, the Society's overseas facilities are mandated to support German technology development and international competitiveness above all else. This means that the Fraunhofer USA centers are being evaluated in terms of their ability to:

- Stimulate export of German technology and equipment.
- Promote Germany as an investment location.
- Penetrate new strategic business and technology fields.
- Expand the scope for Fraunhofer-wide industry and public sector contract research.

Any U.S. partner of a Fraunhofer establishment will have to recognize this German orientation and achieve a balance with their own interests.

5.2.III. Social Market Economy Partnerships Provide Strong Competitive Edge

The Fraunhofer Model, developed in Germany's "social market economy," provides considerable competitive edge when applied in the United States "consumer-driven market economy." The amount and

"...the degree of dependency on German know-how could become an issue."

“...the Fraunhofer partners – government, university, and student/employees – are encouraged to contribute to the marketing of Fraunhofer Society services.”

way in which government subsidies are awarded to each Fraunhofer Institute provides an advantage not only with private sector contract research firms that do not receive public funds, but also with research universities that rely upon a mix of private and public funds. Basic funds provide the means by which each Institute is able to maintain state-of-the-art technology and undertake advanced application oriented basic research in their respective field. Therefore, when bidding on industrial or public sector contracts, the Fraunhofer Institutes can market their full range of research assets without having to include all of their operating costs as part of the bid package. In contrast, fully private sector firms offering comparable research assets would have to factor into their bid proposals much greater overhead costs. In addition, their cost structures tend to make them focus much more on short term research than is the case with the Fraunhofer Society.

Similarly, with more and more universities competing for contract research, the fact that government basic funding supports the acquisition of state-of-the-art technology enables the Fraunhofer Institutes to win research contracts that otherwise may have gone to universities. The presence of a Fraunhofer Institute near a university in Germany has even been observed in some cases as changing the nature of the research performed at the university, including eroding the scope of industrial projects.

Another area of competitive advantage resulting from the Fraunhofer Model is the fact that all of the Fraunhofer partners – government, university, and student/employees – are encouraged to contribute to the marketing of Fraunhofer Society services. This provides a tremendous synergy in attracting new business. Marketing is an ongoing activity driven by the Fraunhofer principle that “a new technology can only capture new markets if and when it has found practical applications⁵.” Government partners, whether Federal or State, are expected to help identify future programs and industrial partners. University partners are expected to ensure that their relationship continues to grow through publicly or industry funded projects. Finally, the Fraunhofer student/employees are trained to include marketing as part of their day-to-day work; in fact, they are evaluated on the basis of how much industry revenue they generate individually. When they enter industry upon “graduation” from a Fraunhofer Institute, they are also expected to be part of an informal Fraunhofer Society network promoting the organization to business.

5.2.IV. Focus on “Entrepreneurial” Interests Not “Economic Development”

While government partners see economic development as the ultimate payoff of their relationship with the Fraunhofer organization, it should be noted that this is not what motivates the Fraunhofer Model. The Fraunhofer Society’s own growth and development takes precedence over economic development. In other words, the Fraunhofer Society’s ability to generate “industrial” and “project” financing, and the resulting “public” subsidies, is the driver, as opposed to “economic development” per se. The Fraunhofer Society will only pursue economic development if it “pays” or contributes to the overriding performance of its revenue ratios. Whether located in Germany or elsewhere, if government subsidies are not maintained and the government and university partners do not generate sufficient industry and public contracts, together with those generated by the Fraunhofer Institute itself, then the organization concerned will be closed. In fact the Fraunhofer Society is quite clear that it can not be purchased at any price solely for the purpose of economic development.

“The Fraunhofer Society’s own growth and development takes precedence over economic development.”

5.2.V. Patent Policy Results in Fraunhofer Control of Patents

The Fraunhofer Society patent policy is structured to benefit the Fraunhofer over its industry and university partners. As noted in a recent study of the U.S. and German technology transfer systems, the usual practice is for inventions derived from research projects to be registered by the Institute conducting the work⁶. The Fraunhofer partners may get an exclusive license but only for their specific application. In contrast, the Fraunhofer is free to license the patented technology to another company for a different application. As a result of this patent policy the Fraunhofer Society has become one of the most active patent assignees in Germany, filing approximately one patent a day (on the international level the Fraunhofer Society ranked 28th place in 1995, with 293 applications⁷). Since future customers have access to patents resulting from completed research work, their cumulative value further enhances the Fraunhofer Society’s marketability and profitability.

“...the Fraunhofer is free to license the patented technology to another company for a different application.”

5.2.VI. Not-for-Profit Tax Status with Commercial Focus

The Fraunhofer Society’s decision to establish facilities in the United States will probably require some modification to how they typically

conduct business to adapt to the cultural and legal differences in business practices between Germany and the United States. For example, given the fact that the Fraunhofer-Gesellschaft is setting up in Germany two private, profit-oriented innovation centers to help close the gap between Institutes and the market, emphasizes the importance of the Fraunhofer USA not overstepping its not-for-profit status in the U.S. in light of the close ties that are maintained with the German-based Fraunhofer Society. Another area of concern from a U.S. perspective would be the control of certain U.S. technologies that may be transferred back to Germany. Overall, U.S. partners and clients of the Fraunhofer USA network, as well as competitors will have to understand the hybrid nature of the Fraunhofer organization, that is, its not-for-profit status with commercial focus. While Fraunhofer USA is a not-for-profit organization and each U.S.-based resource/research center is affiliated with a university, it does have a major commercial focus, and competes quite aggressively with private-sector establishments. In fact, when a Fraunhofer Institute is involved in collaborative work, whether with universities or other laboratories, it has a reputation of seeking all of the industrial contracts that are possible (as well as all of the patent rights which may follow), regardless of the interests of the collaborators.

5.3. Conclusion

As the world has become more global and dominated by technology-intensive industries, the quality of a nation's innovation system has acquired greater importance. Not only must nations be adept at responding to changing research priorities but they also must find a way to prevent rising costs from becoming an obstacle to pursuing leading-edge R&D. This is especially important with respect to activities that promote firms' competitiveness.

Government, industry, and university partnerships, by combining different strengths, can optimize technology capabilities and budgets. When developed in concert with State and local economic development organizations, they can also be instrumental in promoting the establishment of industrial R&D facilities and regional economic growth.

The range of partnership models, however, is considerable. Whether the partnership strategy involves creating organizations like Germany's Fraunhofer Society (or assisting in their expansion throughout the United States), more familiar research parks or industry clusters such

“Government, industry, and university partnerships, by combining different strengths, can optimize technology capabilities and budgets.”

as found in Massachusetts, Greater Washington D.C., North Carolina, and California, et al, or some altogether different solution, it can only be determined after careful assessment of future needs and resources available. Whatever vision is defined and chosen to work toward, though, will only be achieved by strategically drawing upon each partners' strength to mutual advantage and understanding their goals and drivers.

Given the core strength of the U.S. innovation system – flexibility, adaptability, and diversity – the establishment of the Fraunhofer USA network offers an opportunity for industry to optimize its research efforts, particularly for incremental, low-risk, improvements. At the same time, government can obtain further insights into the benefits of research collaboration involving industry, university, and public resources. While certain aspects of Fraunhofer USA may give cause for concern about competition and creativity, among other issues, the more the U.S. innovation system can demonstrate responsiveness to the example of the Fraunhofer Model, the more it will be able to contribute to U.S. industrial competitiveness.

5.4. End Notes

¹ Is the Wellspring of Innovation Running Dry?

(Peter J. Nicholson, May 12, 1997)

² Technology Transfer Systems in the United States and Germany: Lessons and Perspectives (National Academy Press, Washington, D.C., 1997)

³ Technology Transfer Systems in the United States and Germany: Lessons and Perspectives (National Academy Press, Washington, D.C., 1997)

⁴ Technology Transfer Systems in the United States and Germany: Lessons and Perspectives (National Academy Press, Washington, D.C., 1997)

⁵ Profile of the Fraunhofer-Gesellschaft: Its Purpose, Capabilities and Prospects (Fraunhofer-Gesellschaft brochure)

⁶ Technology Transfer Systems in the United States and Germany: Lessons and Perspectives (National Academy Press, Washington, D.C., 1997)

⁷ Annual Report 1995 (Fraunhofer-Gesellschaft)

Appendix “A”: THE FRAUNHOFER NETWORK

The worldwide research network of the Fraunhofer-Gesellschaft can be contacted on the Internet at <<http://www.fhg.de>>, or by contacting one or more of the following:

1. FRAUNHOFER IN GERMANY

Fraunhofer-Gesellschaft Department of International Cooperation

Dieter R. Fuchs
LeonrodstraBe 54
D-80636 Munchen
Tel: +49 89 1205 125
Fax: +49 89 1205 317
E-Mail: fuchs@zv.fhg.de

Fraunhofer-Gesellschaft Research and Management Planning

LeonrodstraBe 54
D-80636 Munich
Germany

Fraunhofer-Gesellschaft Press and Public Relations

LeonrodstraBe 54
D-80636 Munich
Germany

2. FRAUNHOFER IN THE U.S.

Fraunhofer Center for Research in Computer Graphics, Inc.

Bertram Herzog
167 Angell Street
P.O. Box 2555
Providence, RI 02906, USA
Tel: 1 401 453 6363
Fax: 1 401 453 0444
E-Mail: pbono@crcg.edu
mmacedon@crcg.edu
Internet: <http://www.crcg.edu>

**Fraunhofer Technology Center
Hialeah****Biomedical Engineering**

Rainer Schmitt

601 West 20th Street

Hialeah, Fl 33010, USA

Tel: 1 305 819 5579

Fax: 1 305 819 5579

E-Mail: info@fraunhofer.org

**Fraunhofer Resource Center
Delaware****Near-Net-Shape Manufacturing**

Harald H. Eifert

1 Innovation Way, Suite 301

Newark, DE 19711, USA

Tel: 1 302 369 6761

Fax: 1 302 369 6763

E-Mail: info@frc-de.fraunhofer.org

Internet: <http://www.frc-de.fraunhofer.org>

**Fraunhofer Center
Maryland****Software Engineering**

Victor Basili

University of Maryland

3115 Ag/Life Science Surge Bldg. #296

College Park, MD 20742, USA

Tel: 1 301 405 6541

Fax: 1 301 405 6638

E-Mail: info@fc-md.fraunhofer.com

Internet: <http://fc-md.umd.edu>

**Fraunhofer Resource Center
Massachusetts****Production Technology**

Ulf von Haacke

15 St. Mary's Street

Boston, MA 02215, USA

Tel: 1 617 353 1888

Fax: 1 617 353 1896

E-Mail: UVH@Fraunhofer.bu.edu

Internet: <http://frc-mass.bu.edu>

Fraunhofer Resource Center

Michigan

Laser Technology

Stefan Heinemann

2901 Hubbard Rd.

Ann Arbor, MI 48105-2467, USA

Tel: 1 313 769 5825

Fax: 1 313 769 9428

E-Mail: frank@frc.engin.unmich.edu

Internet: <http://frc.engin.umich.edu>

Fraunhofer USA, Inc.

Headquarters

Frank Treppe

Donna Hart

24 Frank Lloyd Wright Drive

Ann Arbor, MI 48106-0335, USA

Tel: 1 313 930 5510

Fax: 1 313 930 5515

E-Mail: info@fraunhofer.org

Internet: <http://fraunhofer.org>

3. FRAUNHOFER IN ASIA

Fraunhofer Asia

Representative Office Malaysia

Peter Nicolaisen

Christian Hesse

Wisma Man Shoon, 3rd Floor

Lot 18, Jalan 19/1, Section 19

46300 Petaling Jaya

Selangor, Malaysia

Tel: +603 756 0873

Fax: +603 754 4270

E-Mail: fhgasia@asiaconnect.conn.my

Internet: <http://www.ipa.fhg.de/~asien>

Fraunhofer Asia
Representative Office Singapore

Dagmar Martin-Vlsshage
3 Science Park Drive #04-15
Singapore Science Park 1
Singapore 118223
Tel: +65 777 7656
Fax: +65 777 2993
E-Mail: fhgsin@singnet.com.sg

Fraunhofer Asia
Representative Office China

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Poly Plaza, Room 509
Dongzhimen Nandajie 14
Beijing, China 100 027
Tel: +86 10 6500 1188 509
Fax: +86 10 6501 9023

Appendix “B”: FEDERAL AND STATE COOPERATIVE TECHNOLOGY PROGRAMS

1. FEDERAL COOPERATIVE TECHNOLOGY PROGRAMS

Department of Agriculture:

Alternative Agricultural Research and Commercialization (AARC)

Office of the Director

Alternative Agricultural Research and Commercialization (AARC)

U.S. Department of Agriculture

14th and Independence Ave., SW

Washington, D.C. 20250

TEL: (202) 401-4860

Extension Service (ES)

Office of the Administrator

Extension Service (ES)

U.S. Department of Agriculture

14th and Independence Ave., SW

Washington, D.C. 20250

TEL: (202) 720-3377

Small Business Innovation Research (SBIR)

Office of Small and Disadvantaged Business Utilization

Small Business Innovation Research (SBIR)

U.S. Department of Agriculture

14th and Independence Ave., SW

Washington, D.C. 20250

TEL: (202) 720-7117

Department of Commerce:

Advanced Technology Program (ATP)

Office of the Director

Advanced Technology Program (ATP)

U.S. Department of Commerce

National Institute of Standards and Technology

Gaithersburg, MD 20899-0001

TEL: (301) 975-5187

1-800-ATP-FUND (1-800-287-3863)

OFFICE OF TECHNOLOGY POLICY

Community Economic Adjustment Program

Office of the Director
Community Economic Adjustment Program
Economic Adjustment Division
U.S. Department of Commerce
Washington, D.C. 20230
TEL: (202) 482-2659

Manufacturing Extension Partnership (MEP)

Office of the Director
Manufacturing Extension Partnership (MEP)
U.S. Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001
TEL: (301) 975-5020

Small Business Innovation Research (SBIR)

Small Business Innovation Research (SBIR)
U.S. Department of Commerce
Washington, D.C. 20230
TEL: (301) 713-3565 or (301) 975-4517

Department of Defense:

Manufacturing Technology Program (MANTECH)

Office of the Director of Manufacturing Modernization, DoD
Manufacturing Technology Program (MANTECH)
Office of the Assistant Secretary of Defense
Attn: OASD (P&L) PR/MM
The Pentagon, Room 2B253
Washington, D.C. 20301-8000
TEL: (703) 697-0957

MARITECH Program

Office of the Program Manager
MARITECH Program
4301 North Fairfax Drive
Suite 700
Arlington, VA 22203
TEL: (703) 516-6002

National Consortium for High Performance Computing (NCHPC)

Office of the Chairman
National Consortium for High Performance Computing (NCHPC)
545 Technology Square
Cambridge, MA 02139
TEL: (617) 243-0531

Robert C. Byrd Institute for Advanced Flexible Manufacturing Systems

Office of the Director
Robert C. Byrd Institute for Advanced Flexible Manufacturing Systems
1050 4th Ave.
Huntington, WV 25755
TEL: (304) 696-6242

Semiconductor Manufacturing Technology Consortium (SEMATECH)

Office of the President and CEO
SEMATECH Office
2706 Montopolis Drive
Austin, TX 78741-6499
TEL: (512) 356-3159

Small Business Innovation Research (SBIR), Small Business Technology Transfer Program (STTR)

Office of the Director
Small Business Innovation Research (SBIR)
The Pentagon
Washington, D.C. 20301
TEL: (703) 697-1481
1-800-225-DTIC (1-800-225-3842)

Technology Reinvestment Project (TRP)

Office of the Director
Technology Reinvestment Project (TRP)
3701 N. Fairfax Drive
Arlington, VA 22203-1714
TEL: (703) 696-2237
1-800-DUAL-USE (1-800-382-5873)

Department of Energy:

Defense Programs Small Business Initiative (SBI)

Defense Programs Small Business Initiative Program

Defense Programs Small Business Initiative (SBI)

Technology Transfer Division

Office of Defense Programs

U.S. Department of Energy

Albuquerque Operations Office

Albuquerque, NM 87185-5400

TEL: (505) 845-4947

Energy Extension Service (EES)

Office of the Director, State Energy Programs Division

Energy Extension Service (EES)

State Energy Programs Division

U.S. Department of Energy

Office of Research Efficiency and Renewable Energy

1000 Independence Ave., SW

Washington, D.C. 20585

TEL: (202) 586-9187

Energy Related Inventions Program (ERIP)

Inventions and Innovation Division

Energy Related Inventions Program (ERIP)

U.S. Department of Energy

Office of Energy Efficiency and Renewable Energy

1000 Independence Ave., SW

Washington, D.C. 20585

TEL: (202) 586-1479

Fossil Energy State-Federal Cooperative Program

Office of the Director

Office of Business Operations

Fossil Energy State-Federal Cooperative Program

U.S. Department of Energy

1000 Independence Ave., SW

Washington, D.C. 20585

TEL: (301) 903-2098 or (301) 903-2617

OFFICE OF TECHNOLOGY POLICY

National Industrial Competitiveness through Energy, Efficiency and Economics (NICE3)

National Industrial Competitiveness through Energy, Efficiency and Economics (NICE3)

U.S. Department of Energy

1000 Independence Ave., SW

Washington, D.C. 20585

TEL: (301) 275-4755 or (301) 275-4728 or (202) 586-1641

Small Business Innovation Research (SBIR) and Small Business Technology Transfer Program (STTR)

Office of the Program Manager

Small Business Innovation Research (SBIR)

U.S. Department of Energy

1000 Independence Ave., SW

Washington, D.C. 20585

TEL: (301) 903-3054

DOE Federal Laboratories

Department of Health and Human Services:

Small Business Innovation Research (SBIR) and Small Business Technology Transfer Program (STTR)

PHS SBIR Solicitation Office

Small Business Innovation Research

13687 Baltimore Ave.

Laurel, MD 20707

TEL: (301) 206-9385

Research Training and Special Programs Office, NIH National Institutes of Health

Building 31, Room 5B44

Bethesda, MD 20892

TEL: (301) 496-1968

Department of Labor:

Human Resources Assessment Program (HRAP)

Office of the Chief, Training Policy Staff,
Office of Work-Based Learning
Human Resources Assessment Program (HRAP)
Employee Training Administration
U.S. Department of Labor
200 Constitution Ave., Room N-4649
Washington, D.C. 20210
TEL: (202) 219-5555

Learning Consortia Project

Office of the Chief, Training Policy Staff,
Office of Work-Based Learning
Learning Consortia Project
Employee Training Administration
U.S. Department of Labor
200 Constitution Ave., Room N-4649
Washington, D.C. 20210
TEL: (202) 219-5555

National Workforce Assistance Collaborative

Office of the Project Director
National Workforce Assistance Collaborative
National Alliance of Business
1201 New York Avenue, NW
Washington, D.C. 20005-3917
TEL: (202) 289-2984

**Workforce Development and
Industrial Modernization Project**

Bay State Skills Corporation
101 Summer Street, 3rd Floor
Boston, MA 02110
TEL: (617) 292-5100

Department of Transportation:

Intelligent Vehicle Highway Systems (IVHS)

Office of the Director

IVHS Program Office

U.S. Department of Transportation

Federal Highway Administration

400 Seventh Street SW

Washington, D.C. 20590

TEL: (202) 366-2149

National Magnetic Levitation Initiative (MAGLEV)

Office of Railroad Development

U.S. Department of Transportation

Federal Railroad Administration

400 Seventh Street, SW

Washington, D.C. 20590

TEL: (202) 366-9657

Small Business Innovation Research (SBIR)

Office of the Chief of University Research,

Technology Innovation and Programs

Small Business Innovation Research (SBIR)

Volpe National Transportation Systems Center

Kendall Square

55 Broadway

Cambridge, MA 02142

TEL: (617) 494-2756 or (617) 494-2051

University Transportation Center Program (UTC)

Office of the Director

University Transportation Center Program (UTC)

U.S. Department of Transportation

Research and Special Programs Administration

400 Seventh Street, SW

Washington, D.C. 20590

TEL: (202) 366-5442

Environmental Protection Agency:

Environmental Technology Initiative (ETI)

Office of the Director

Innovative Technology Programs

Environmental Technology Initiative (ETI)

U.S. Environmental Protection Agency

401 M St., SW

Washington, D.C. 20460

TEL: (202) 260-4073

**National Industrial Competitiveness through
Energy, Efficiency, and Economics**

National Industrial Competitiveness through Energy,
Efficiency, and Economics

U.S. Environmental Protection Agency

401 M St., SW

Washington, D.C. 20460

TEL: (202) 260-3575

Small Business Innovation Research (SBIR)

Office of the Program Manager

Small Business Innovation Research (SBIR)

Office of Exploratory Research (8703)

Office of Research and Development

U.S. Environmental Protection Agency

401 M St., SW

Washington, D.C. 20460

TEL: (202) 260-7473

**Superfund Innovative Technology Evaluation Program
(SITE)**

SITE Program Office

U.S. Environmental Protection Agency

Office of Research and Development

401 M St., SW

Washington, D.C. 20460

TEL: (513) 569-7758

National Aeronautics and Space Administration:

Aerospace Industry Technology Program (AITP)

Aerospace Industry Technology Program
Office of Advanced Concepts and Technology
National Aeronautics and Space Administration
Two Independence Square
300 E St., SW
Washington, D.C. 20546
TEL: (202) 358-4659

Centers for the Commercial Development of Space (CCDs)

Office of the Deputy Director
Centers for the Commercial Development of Space
National Aeronautics and Space Administration
Two Independence Square
300 E St., SW
Washington, D.C. 20546
TEL: (202) 358-1996

Field Center Technology Utilization Offices

NASA Headquarters
Office of Advanced Concepts and Technology
National Aeronautics and Space Administration
Two Independence Square
300 E St., SW
Washington, D.C. 20546
TEL: (202) 358-0723

National Technology Transfer Center

National Technology Transfer Center
Wheeling Jesuit College
316 Washington Ave.
Wheeling, WV 26003
TEL: 1-800-678-6882

Regional Technology Transfer Centers (RTTCs)

TEL: 1-800-472-6785

National Science Foundation:

Engineering Research Centers (ERCs)

Office of the Deputy Division Director
Engineering Research Centers
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
TEL: (703) 306-1379

Experimental Program to Stimulate Competitive Research (EPSCoR)

Office of the Program Director
Experimental Program to Stimulate Competitive Research
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
TEL: (703) 306-1683

**Industry/University Cooperative Research Centers (I/UCRs)
State/Industry University Cooperative Research Centers (State/IUCRCs)**

Office of the Program Director
Industry/University Cooperative Research Centers
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
TEL: (703) 306-1383

Materials Research Science and Engineering Centers (MRSECs)

Office of the Program Director
Materials Research Science and Engineering Centers
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230

Science and Technology Centers (STCs)

Office of the Senior Advisor
Science and Technology Centers
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
TEL: (703) 306-1040

Small Business Innovation Research (SBIR) and Small Business Technology Transfer Program (STTR)

Office Head

Small Business Innovation Research

National Science Foundation

4201 Wilson Blvd.

Arlington, VA 22230

TEL: (703) 306-1390

Cross-Agency Programs:

Experimental Program to Stimulate Competitive Research (EPSCoR)

Office of the Program Director

Experimental Program to Stimulate Competitive Research

National Science Foundation

4201 Wilson Blvd.

Arlington, VA 22230

TEL: (703) 306-1683

Federal Laboratory Consortium for Technology Transfer (FLC)

Office of the Administrator

Federal Laboratory Consortium for Technology Transfer

Management Support Office

224 W. Washington, Suite 3

P.O. Box 545

Sequim, VA 98382-0545

TEL: (206) 683-1005

Small Business Innovation Research (SBIR) and Small Business Technology Transfer Program (STTR)

Office of the Administrative Assistant

Small Business Administration (SBA)

Small Business Innovation Research Office

409 Third St., SW

Washington, D.C. 20416

TEL: (202) 205-6450

2. STATE COOPERATIVE TECHNOLOGY PROGRAMS

Chief, Technology and Energy Department
Alabama Department of Economic and Community Affairs
401 Adams Avenue - P.O. Box 5690
Montgomery, AL 36103-5690
TEL: (202) 242-5286

Executive Director
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515
Anchorage, AK 99508-5918
TEL: (907) 272-4333

Energy Director
Arizona Department of Commerce
3800 North Central, Suite 1200
Phoenix, AZ 85012
TEL: (602) 280-1336

President
Arkansas Science & Technology Authority
100 Main Street, Suite 450
Little Rock, AR 72201
TEL: (501) 324-9006

Director, Office of Strategic Technology
California Trade and Commerce Agency
200 East Del Mar Street, Suite 204
Pasada, CA 91105
TEL: (818) 568-9437

Executive Director
Colorado Advanced Technology Institute
1625 Broadway, Suite 700
Denver, CO 80202
TEL: (303) 620-4777 ext. 301

Executive Director
Connecticut Innovations Inc.
40 Cold Spring Rd.
Rocky Hill, CT 06067
TEL: (203) 563-5851

OFFICE OF TECHNOLOGY POLICY

Director

Delaware Development Office

99 Kings Highway, P.O. Box 1401

Dover, DE 19903

TEL: (302) 739-4271

High Technology Office

Florida Department of Commerce

Collins Building, Suite 128

107 West Gaines Street

Tallahassee, FL 32399-2000

TEL: (904) 487-3134

Director

Georgia Office of Planning and Budget

254 Washington Street, Suite 624

Atlanta, GA 30334

TEL: (404) 656-3820

Executive Director

Hawaii High Technology Development Corporation

300 Kahelu Ave., Suite 35

Mililani, HI 96789

TEL: (808) 625-5293

Deputy Director

Idaho Department of Commerce

700 W. State Street, 2nd Floor

Boise, ID 83720-2700

TEL: (208) 334-2470

Executive Director

Illinois Science Advisory Committee

107 Stratton Building

Springfield, IL 62706

TEL: (217) 782-5189

President

**Indiana Business Modernization and
Technology Corporation**

One North Capitol, Suite 925

Indianapolis, IN 46204

TEL: (317) 635-3058 ext.31

OFFICE OF TECHNOLOGY POLICY

Deputy Director
Wallace Technology Transfer Foundation of Iowa
200 East Grand Ave., Suite 130
Des Moines, IA 50309-1827
TEL: (515) 243-1487

President
Kansas Technology Enterprise Corporation
112 W. 6th Street, Suite 400
Topeka, KS 66603
TEL: (913) 296-5272

Executive Director, Office of Business and Technology
Kentucky Cabinet for Economic Development
Capitol Plaza Tower, 24th Floor
Frankfort, KY 40601
TEL: (502) 564-7670

Director, Office of Technology
Louisiana Department of Economic Development
101 France Street, Suite 306
Baton Rouge, LA 70802
TEL: (504) 342-5388

President
Maine Science and Technology Foundation
87 Withrop Street
Augusta, ME 04330
TEL: (207) 621-6350

Director
Office of Federal Facilities and Technology
217 East Redwood St., 23rd Floor
Baltimore, MD 21202
TEL: (410) 333-6901

Deputy Secretary for Defense Diversification and Technology Transfer
Massachusetts Executive Office of Economic Affairs
1 Ashburton Place, Room 2101
Boston, MA 02108
TEL: (617) 727-3206

OFFICE OF TECHNOLOGY POLICY

Deputy Director/Policy Advisor
Michigan Office of the Governor
111 South Capitol, Olds Plaza Building
Lansing, MI 48933
TEL: (517) 373-7949

Executive Director
Minnesota Technology Inc.
111 Third Avenue, South Suite 400
Minneapolis, MN 55401
TEL: (612) 338-7722

Director, Community and Economic Development Center
Mississippi State University
240 Giles Building
P.O. Drawer AQ
Mississippi State, MS 39762
TEL: (601) 325-2547

Assistant Director
Missouri Department of Economic Development
301 West High Street, Room 680
P.O. Box 1157
Jefferson City, MO 65102
TEL: (314) 751-5095

Executive Director
Montana Science and Technology Alliance
46 North Last Chance Gulch
Helena, MT 59620
TEL: (406) 449-2778

Dean, College of Engineering and Technology
Science Advisor to the Governor of Nebraska
University of Nebraska
W181 Nebraska Hall
Lincoln, NE 68588-0501
TEL: (402) 472-3181

OFFICE OF TECHNOLOGY POLICY

Director
Nevada Washington Office
444 N. Capitol Street, Suite 209
Washington, D.C. 20001
TEL: (202) 624-5405

Director
Division of Business and Economic Development
New Hampshire Division of Economic Development
172 Pembroke Road
Concord, NH 03302-0856
TEL: (603) 271-2341

Executive Director
New Jersey Commission on Science and Technology
20 West State Street, CN-832
Trenton, NJ 08625-0832
TEL: (609) 633-2740

Secretary
New Mexico Department of Economic Development
1100 St. Francis Drive, Joseph Montoya Building
Santa Fe, NM 87503
TEL: (505) 827-0381

Executive Director
New York State Science and Technology Foundation
99 Washington Ave., Suite 1730
Albany, NY 12210
TEL: (518) 474-4349

Advisor to the Governor for Policy, Budget, and Technology
North Carolina Department of Administration
116 West Jones Street
Raleigh, NC 27603
TEL: (919) 715-0960

Assistant to the Dean
North Dakota School of Engineering and Mines
P.O. Box 8372, University Station
Harrington Hall, Room 100, Campus Drive
Grand Forks, ND 58202
TEL: (701) 777-5128

OFFICE OF TECHNOLOGY POLICY

Manager

Ohio's Thomas Edison Program

77 South High Street
Columbus, OH 43266-0101
TEL: (614) 466-3086

President

**Oklahoma Center for Advancement of
Science and Technology**

301 N.W. 63rd Street, Suite 110
Oklahoma City, Ok 73116-7906
TEL: (405) 848-2633

Vice Chancellor and Dean, College of Engineering, OSU

Oregon Center for Advanced Technology Education

1900 NW Gibbs Drive, Building E 3, Suite 150
Beaverton, OR 97006
TEL: (503) 737-3101

Director, Office of Technology Development

Pennsylvania Department of Commerce

352 Forum Building
Harrisburg, PA 17120
TEL: (717) 787-4147

Rhode Island Department of Economic Development

7 Jackson Walkway
Providence, RI 02903
TEL: (401) 277-2601

Executive Director

South Carolina Research Authority

1330 Lady Street, Suite 503
Columbia, SC 29201
TEL: (803) 799-4070

President

South Dakota School of Mines and Technology

501 East St. Joseph Street
Rapid City, SD 57701
TEL: (605) 394-2411

OFFICE OF TECHNOLOGY POLICY

Advisor to the Governor for Science and Technology
**Tennessee Department of Economic and
Community Development**
320 6th Ave. North, Rachel Jackson Bldg 6th Floor
Nashville, TN 37243-0405
TEL: (615) 741-2994

Program Manager, Office of Advanced Technology
Texas Department of Commerce
410 East 5th Street
Austin, TX 78701
TEL: (512) 320-9561

Director, Business Creation
**Utah Department of Community and
Economic Development**
324 South State, Suite 500
Salt Lake City, UT 84114
TEL: (801) 538-8770

Policy Analyst
Vermont Office of the Governor
5th Floor, Pavilion Building
Montpelier, VT 05602
TEL: (802) 828-3326

Secretary
Secretariat of Commerce and Trade
Commonwealth of Virginia
9th Street Office Building
Richmond, VA 23212
TEL: (804) 786-7831

Special Assistant to the Director
**Washington Department of Trade and
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3. NOT-FOR-PROFIT COLLABORATIVE RESEARCH CONSORTIUM

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Interviews

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Dr. Michael Macedonia, Vice President, Fraunhofer Center for Research in Computer Graphics, Inc. (USA), 67 Angell Street, P.O. Box 2555, Providence, RI 02906, (401) 453-6363.

Dr. Michael Wozny, Professor of Engineering, Rensselaer Polytechnic Institute, Rochester, NY.

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